

SECTION 5

WATER QUALITY PROJECTIONS



Environmental
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The ultimate goal of developing an updated water quality model of Opequon Creek is to provide a tool to determine the assimilative capacity of the creek for point source permitting of the PMWWTF and OWRF. In addition, the FWSA is also considering a new Northern Wastewater Reclamation Facility (NWRF) as part of its wastewater planning. The calibrated DIURNAL model is used for these water quality projection analyses with the creek flow set at the 7Q10 low-flow and at summer creek temperatures.

Figure 31 presents historical creek flow data from the two USGS gages on the creek from 1945 to 2005. The grey line in the top panel represents an estimate of the Stephens City flow based on a drainage area ratio to the Berryville gage flows. This data was used by VDEQ to determine a 7Q10 low-flow for the creek at the Berryville gage. The 7Q10 low-flow is the minimum 7-day average flow that occurs once in ten years and was estimated by VDEQ to equal 1.5 cfs (VDEQ, 2004). This estimated 7Q10 low-flow accounts for the start-up of the OWRF in July 1988 by only using the flow records prior to this date. This 7Q10 low-flow at the Berryville gage is used to develop flows along the length of the creek based on the incremental and tributary drainage areas as described in the geometry calibration section.

Creek temperature data was available in 2003 from OWRF staff sampling upstream from the discharge and is presented in Figure 32 along with the creek flow at the Berryville gage. This figure highlights the annual creek temperature variation, which ranges from 1 to 22°C, with the maximum temperatures occurring in the summer during low-flow conditions. In order to assign, an upper percentile creek temperature for the water quality model projections, a creek temperature of 23.6°C was assigned based on the critical condition creek modeling completed for the PMWWTF proposed expansion (Donohue & Associates, 1992).

The calibration rates presented in Tables 7 and 8 are used for the water quality projections and are corrected to the critical creek temperature of 23.6°C since these rates are assigned at 20°C. In order to investigate the DO impacts under different ambient light conditions (sunny vs. cloudy), the Pmax and R rates for both the 10/13-14 and 11/3 surveys were used to complete the water quality projections. In addition, the geometry is also adjusted as a function of creek flow as is the reaeration rate since it is a function of the creek velocity.

A number of water quality projections were completed for a range of effluent flow and quality scenarios at four flow tiers that included a combination of discharge conditions from the PMWWTF, OWRF, NWRF and the County Landfill. These conditions are presented in Tables 9 through 11 and resulted in a total of 20 water quality projection model runs.

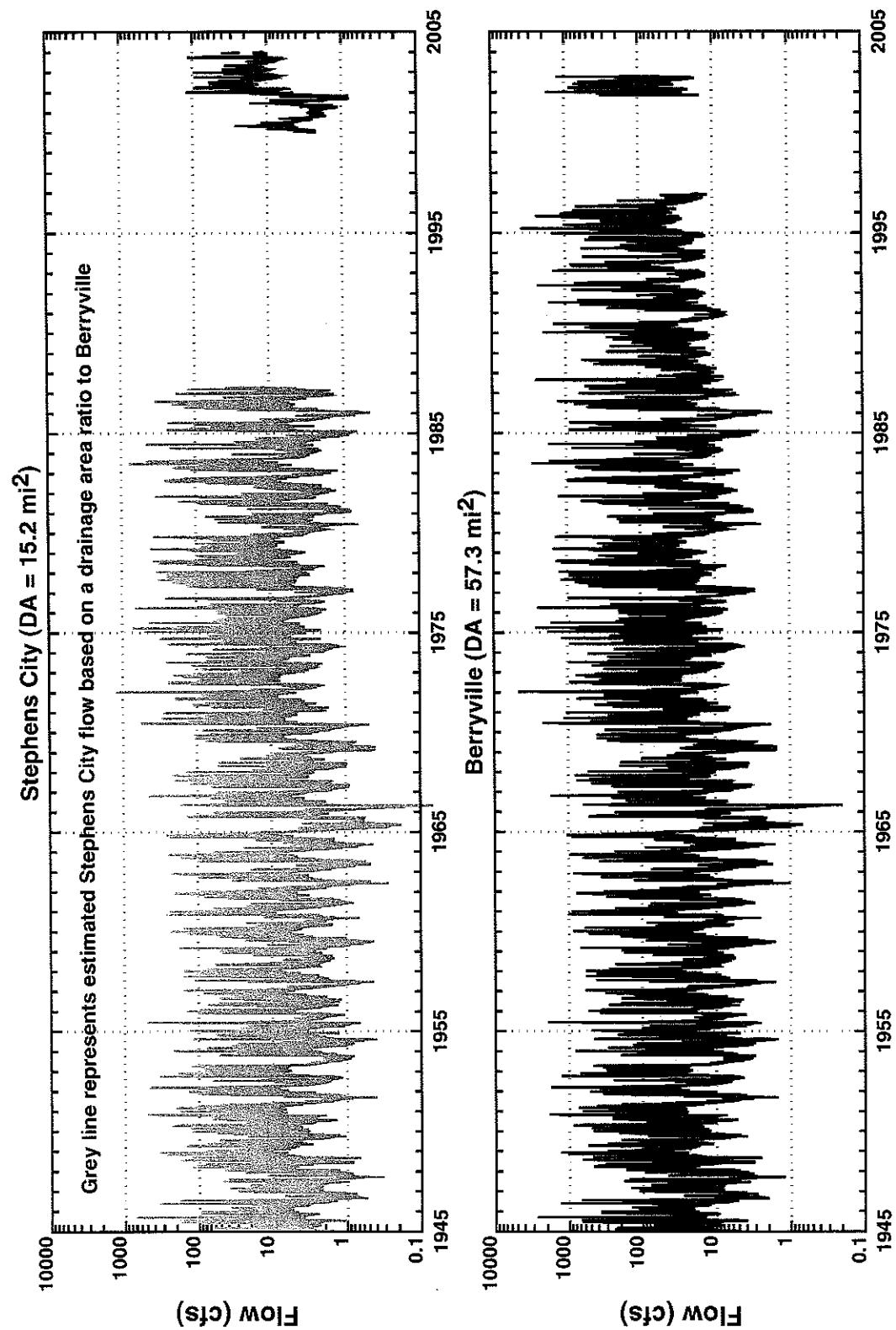


Figure 31. Opequon Creek USGS Gage Flows (1945-2004)

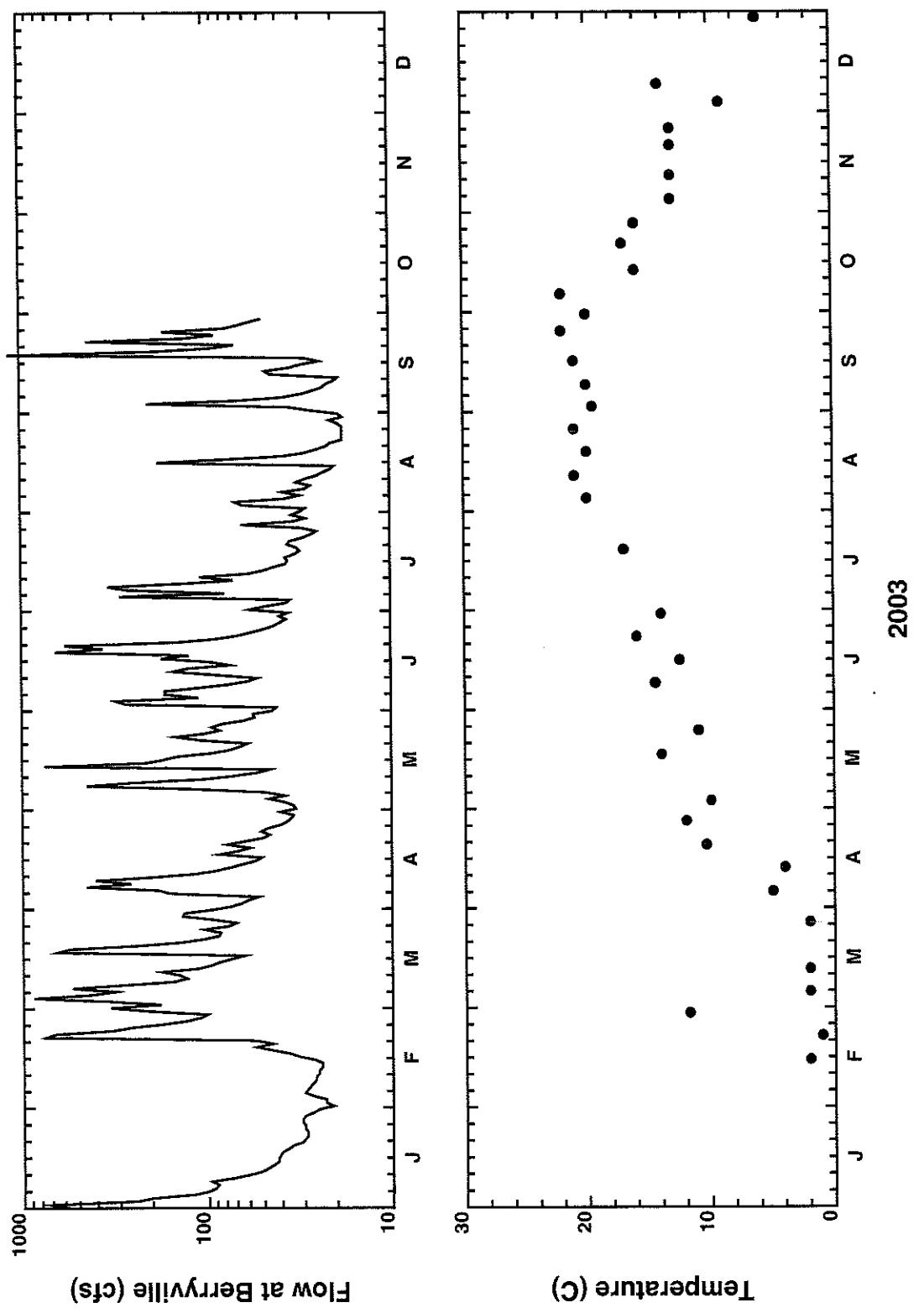


Figure 32. Opequon Creek Flow and Temperature Data for 2003
(Temperature Data from OWRF Staff Upstream of Discharge, Flow Data From USGS)

Table 9. Discharge Flow Tiers for Projections

Flow Tier	PMWWTF Flow (MGD)	OWRF Flow (MGD)	NWRF Flow (MGD)	Landfill Flow (MGD)
1	2.0	6.4	0.0	0.15
2	3.0	8.0	2.0	0.15
3	4.0	12.0	4.0	0.15
4	5.0	16.0	6.0	0.15

Table 10. Discharge Quality Scenarios for Projections

Discharge Scenario	PMWWTF	OWRF	NWRF	Landfill
1	Current Permit	BNR	No Flow	Current Permit
2	Advanced BNR	ENR	No Flow	Future Permit
3	BNR	Advance BNR	No Flow	Future Permit
4	BNR	Advance BNR	BNR	Future Permit
5	ENR	ENR	ENR	Future Permit

BNR - Biological Nutrient Removal

Advanced BNR - Advanced Biological Nutrient Removal

ENR - Enhanced Nutrient Removal

Table 11. Discharge Effluent Quality for Projections

Parameter	Current PMWWTF Permit	Current OWRF/NWRF Permit	BNR	Advanced BNR	ENR	Landfill Current Permit	Landfill Future Permit
TN	20.0	8.0	8.0	5.0	3.0	20.5	8.1
OrgN	2.0	2.0	2.0	2.0	1.5	7.1	2.7
NH ₃	1.6	1.6	1.6	1.0	1.0	12.9	4.9
NO ₂ +NO ₃	16.4	4.4	4.4	2.0	0.5	0.5	0.5
TP	2.0	1.5	1.5	0.5	0.3	1.5	1.5
BOD ₅	7.5	7.1	7.5/7.1 ^a	7.5/7.1 ^a	7.5/7.1 ^a	25	9.5
CBOD ₅	38.6	33.9	38.6/33.9 ^a	38.6/33.9 ^a	38.6/33.9 ^a	75	28.5
DO	7.1	7.1	7.1	7.1	7.1	7.1	7.1

^a - PMWWTF / OWRF or NWRF

These ranges of discharge conditions were evaluated with the calibrated DIURNAL model of Opequon Creek under 7Q10 low-flow and summer creek temperature conditions (critical summer low-flow). The resulting water quality model output is presented in the same format as Figure 28 for the two Pmax and R levels in the appendices as follows:

- Appendix 2 – Tier 1, Scenarios 1 to 5 – Cloudy Pmax & R Rates;
- Appendix 3 – Tier 2, Scenarios 1 to 5 – Cloudy Pmax & R Rates;
- Appendix 4 – Tier 3, Scenarios 1 to 5 – Cloudy Pmax & R Rates;
- Appendix 5 – Tier 4, Scenarios 1 to 5 – Cloudy Pmax & R Rates;
- Appendix 6 – Tier 1, Scenarios 1 to 5 – Sunny Pmax & R Rates;
- Appendix 7 – Tier 2, Scenarios 1 to 5 – Sunny Pmax & R Rates;
- Appendix 8 – Tier 3, Scenarios 1 to 5 – Sunny Pmax & R Rates; and
- Appendix 9 – Tier 4, Scenarios 1 to 5 – Sunny Pmax & R Rates.

In order to simplify the model output, Table 12 presents a summary of the model DO output (minimum daily average DO and minimum DO) for each ambient light condition (cloudy and sunny). For the cloudy condition, the daily average creek DO for all discharge cases is always greater than the 5 mg/L State DO standard and typically greater than 7 mg/L at the critical summer, low-flow creek conditions. The daily minimum DO for the cloudy condition is always greater than the 4 mg/L State DO standard and typically greater than 6 mg/L for all discharge cases. For the sunny condition, the daily average creek DO for all discharge cases is always greater than the 5 mg/L State DO standard and typically greater than 6 mg/L at the critical summer, low-flow creek conditions. The daily minimum DO for the summer condition is always greater than the 4 mg/L State DO standard for all discharge cases. The major difference between the cloudy and sunny conditions is that there are greater daily diurnal swings in DO with greater daily average DO and lower minimum DO levels for the sunny condition as opposed to the cloudy condition. It should be noted that for all discharge cases at critical summer, low-flow creek conditions during either cloudy or sunny conditions that State DO standards will be maintained throughout Opequon Creek from just upstream of the PMWWTF to approximately 26 miles downstream. This length of the creek includes discharges from the PMWWTF, County Landfill, OWRF and the potential new discharge from NWRF.

Table 12. Opequon Creek DO Water Quality Projection Results

Case	Cloudy Conditions		Sunny Conditions	
	Min Avg DO	Min DO	Min Avg DO	Min DO
Tier 1/Scen 1	7.15	5.84	6.00	4.16
Tier 1/Scen 2	7.34	6.07	6.19	4.55
Tier 1/Scen 3	7.28	6.05	6.13	4.46
Tier 1/Scen 4	7.28	6.05	6.13	4.46
Tier 1/Scen 5	7.34	6.07	6.19	4.55
Tier 2/Scen 1	7.12	6.05	5.96	4.12
Tier 2/Scen 2	7.29	6.23	6.13	4.42
Tier 2/Scen 3	7.22	6.05	6.07	4.27
Tier 2/Scen 4	7.22	6.05	6.08	4.27
Tier 2/Scen 5	7.29	6.23	6.14	4.42
Tier 3/Scen 1	7.06	6.15	5.90	4.55
Tier 3/Scen 2	7.22	6.32	6.05	4.71
Tier 3/Scen 3	7.15	6.24	5.98	4.55
Tier 3/Scen 4	7.16	6.24	6.02	4.55
Tier 3/Scen 5	7.23	6.32	6.08	4.71
Tier 4/Scen 1	7.23	6.43	6.09	4.83
Tier 4/Scen 2	7.36	6.59	6.23	4.97
Tier 4/Scen 3	7.30	6.43	6.16	4.83
Tier 4/Scen 4	7.32	6.43	6.20	4.83
Tier 4/Scen 5	7.38	6.59	6.27	4.97

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REFERENCES



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- Donohue & Associates, 1992. A Wasteload Allocation Study for the Proposed Expansion of the Parkins Mills Wastewater Treatment Plant.
- HydroQual, Inc., 1997. Evaluation of Water Quality Based Effluent Limits for an Expanded Opequon Water Reclamation Facility.
- State Water Control Board, Valley Regional Office, 1978. Modeling Report Opequon Creek Basin, Proposed Frederick-Winchester Service Authority Facility.
- USEPA, 1986. Memorandum: Guidelines for Using the Tsivoglou Reaeration Equation to Adjust Measured Reaeration Rates for Low Flow Conditions.
- Virginia Department of Environmental Quality, 2004. Personal communication from Larry Hough (Fax dated 3/30/2004).
- Virginia Department of Environmental Quality, 2004. Memorandum - Department of Environmental Quality, Valley Regional Office from Eric Aschenbach to Trevor Wallace (Flow Frequency Determination, Parkins Mill STP - VPDES Permit No. VA0075191, Frederick County (9/16/2004).

APPENDIX 1

2004 OPEQUON CREEK LABORATORY AND FIELD DATA



Environmental
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Opequon Creek Water Quality Survey - 10/13/2004 (PM)

Station	MP	NO ₂ +NO ₃ (mg/NL)	NH ₃ (mg/NL)	TKN (mg/L)	PO ₄ (mgP/L)	TP (mgP/L)	TSS mg/L	VSS mg/L	Chla ug/L	BOD ₅ mg/L
M1	-0.221	2.382	0.002	0.098	0.004	0.007	1.57	0.43	1.49	0.575
M2	0.190	4.728	0.004	0.228	0.334	0.466	1.27	0.47	1.59	0.575
M3	1.141	5.328	0.004	0.297	0.479	0.610	1.17	0.47	1.19	0.600
M4	1.803	5.281	0.005	0.225	0.449	0.527	0.83	0.23	0.90	0.600
M5	3.015	5.831	0.004	0.269	0.684	0.653	0.64	0.44	1.35	0.650
M6	4.022	4.169	0.005	0.214	0.294	0.397	0.64	0.30	1.28	0.600
M7	5.408	4.440	0.003	0.235	0.397	0.438	0.83	0.58	1.40	1.000
M8	7.081	4.922	0.003	0.319	0.314	0.396	0.80	0.40	1.22	0.650
T1		0.032	0.004	0.251	0.003	0.010	1.30	0.43	2.02	0.650
T2		0.200	0.003	0.167	0.003	0.007	0.80	0.37	1.96	0.625
M6 Dup	4.022	4.191	0.002	0.203	0.303	0.381	0.77	0.37	1.45	0.525
M9	8.019	4.806	0.002	0.288	0.336	0.438	0.53	0.67	1.01	0.550
M10	9.587	4.728	0.002	0.246	0.295	0.408	0.40	0.40	1.25	0.750
M11	11.291	4.647	0.002	0.248	0.278	0.368	0.70	0.33	0.78	0.950
M12	11.705	4.244	0.011	0.428	0.201	0.284	0.83	0.80	0.68	1.150
M13	12.973	2.746	0.007	0.279	0.062	0.112	1.03	0.57	1.01	0.450
T3		2.228	0.003	0.218	0.004	0.008	0.17	0.117	0.46	0.200
T4		1.939	0.003	0.128	0.003	0.008	2.57	0.50	2.03	0.350
T5		1.655	0.003	0.092	0.002	0.006	4.02	0.77	1.10	0.250
T6		2.698	0.002	0.085	0.003	0.008	1.42	0.40	0.40	0.225
M14	14.792	2.849	0.004	0.244	0.054	0.113	0.76	0.60	1.44	0.400
M15	17.113	2.812	0.004	0.204	0.052	0.113	0.58	0.53	1.05	0.500
M16	19.581	2.763	0.005	0.168	0.048	0.106	1.43	0.50	1.45	0.350
M17	21.036	2.695	0.007	0.199	0.041	0.100	0.89	0.47	1.23	0.400
M18	24.019	1.508	0.009	0.171	0.041	0.095	1.30	0.43	0.99	0.400
M19	25.843									
T7		1.500	0.006	0.166	0.003	0.009	1.00	0.40	0.82	0.325
M13 FDup	12.973	2.760	0.009	0.538	0.056	0.120	1.17	0.60	1.03	0.500
M15 FDup	17.113	2.809	0.010	0.292	0.052	0.108	0.73	0.23	1.12	0.400
PMWWTF		35.468	0.035	1.115	0.784	6.527	0.73	0.67	0.59	NM
OWRF		4.845	0.034	1.492	0.019	0.190	4.00	3.15	0.17	NM
<u>Field Duplicates</u>										
M6	4.022	4.169	0.005	0.214	0.294	0.397	0.64	0.30	1.28	
M6 Dup	4.022	4.191	0.002	0.203	0.303	0.381	0.77	0.37	1.45	
RPD	0.526	85.714	5.276	3.015	4.113	18.53	20.96	12.12	2.24	
M13	12.973	2.746	0.007	0.279	0.062	0.112	1.03	0.57	1.01	
M13 FDup	12.973	2.760	0.009	0.538	0.056	0.120	1.17	0.60	1.03	
RPD	0.509	25.000	63.403	10.169	6.897	12.12	5.71			
M15	17.113	2.812	0.004	0.204	0.052	0.113	0.58	0.53	1.05	
M15 FDup	17.113	2.809	0.010	0.292	0.052	0.108	0.73	0.23	1.12	
RPD	0.107	85.714	35.484	0.000	4.525	23.73	78.26			

Opequon Creek Water Quality Survey - 10/14/2004 (AM)

Station	MP	NH3 (mgN/L)	TKN (mgN/L)	PO4 (mgP/L)	TP (mgP/L)	TSS mg/L	VSS mg/L	ChlA ug/L	BOD5 mg/L
M1	-0.221	2.399	0.005	0.143	0.005	1.60	0.80	1.69	NM
M2	0.190	6.013	0.007	0.344	0.712	0.799	0.73	1.80	NM
M3	1.141	5.941	0.005	0.372	0.645	0.773	1.60	0.43	1.84
M4	1.803	5.812	0.009	0.312	0.617	0.733	0.87	0.47	NM
M5	3.015	4.342	0.007	0.413	0.344	0.444	1.00	0.20	1.59
M6	4.022	5.003	0.006	0.321	0.466	0.588	0.80	0.40	NM
M6 FdUp	4.022	4.961	0.006	0.340	0.484	0.553	0.57	0.27	1.45
M7	5.408	2.991	0.006	0.340	0.621	0.655	1.00	0.30	NM
M8	7.081	4.686	0.006	0.328	0.275	0.276	0.83	0.53	NM
T1		0.051	0.005	0.300	0.004	0.010	1.53	0.50	NM
T2		0.150	0.007	0.204	0.003	0.006	0.70	0.37	NM
M9	8.019	4.415	0.008	0.358	0.234	0.399	0.90	0.47	1.32
M10	9.587	4.688	0.006	0.410	0.252	0.417	0.93	0.33	1.58
M11	11.291	4.202	0.008	0.280	0.202	0.328	0.47	0.37	1.00
M12	11.705	3.995	0.015	0.618	0.151	0.276	1.03	0.87	NM
M13	12.973	3.248	0.006	0.335	0.071	0.156	1.13	0.57	NM
M13 FdUp	12.973	3.240	0.007	0.316	0.067	0.153	1.27	0.47	1.06
T3		0.752	0.056	0.793	0.004	0.064	2.25	1.75	NM
T4		2.042	0.005	0.154	0.002	0.009	1.25	0.75	1.68
T5		1.927	0.006	0.067	0.002	0.005	4.40	0.83	1.26
T6		1.652	0.009	0.047	0.004	0.009	1.67	0.70	NM
M14	14.792	2.962	0.006	0.209	0.049	0.102	1.07	0.27	1.20
M15	17.113	2.820	0.006	0.231	0.061	0.098	1.33	0.43	1.38
M16	19.581	2.840	0.007	0.238	0.041	0.084	2.53	0.73	NM
M17	21.036	2.775	0.007	0.220	0.043	0.082	1.97	0.57	1.85
M17 FdUp	21.036	2.775	0.009	0.237	0.045	0.084	1.60	0.57	1.70
M18	24.019	2.465	0.008	0.210	0.036	0.084	1.27	0.57	NM
M19	25.843	2.390	0.006	0.178	0.035	0.063	1.43	0.50	0.45
T7		1.517	0.005	0.145	0.003	0.009	1.10	0.30	1.11
PMWWTF		35.801	0.018	2.237	7.840	6.677	12.90	10.55	1.07
OWRF		2.939	0.035	1.372	0.019	0.178	3.05	3.05	2.10
<u>Field Duplicates</u>									
M6	4.022	5.003	0.006	0.321	0.466	0.588	0.80	0.40	1.36
M6 FdUp	4.022	4.961	0.006	0.340	0.484	0.553	0.57	0.27	1.45
RPD		0.843	0.000	5.749	3.789	6.135	34.15	40.00	6.24
M13	12.973	3.248	0.006	0.335	0.071	0.156	1.13	0.57	1.02
RPD		0.247	0.007	0.316	0.067	0.153	1.27	0.47	1.06
M17	21.036	2.775	0.007	0.220	0.043	0.082	1.97	0.57	1.85
RPD		0.000	0.009	0.237	0.045	0.084	1.60	0.57	1.70
		25.000		7.440	4.545	2.410	20.55	0.00	8.43

Opequon Creek Water Quality Survey - 10/13-14/2004 (AM/PM)

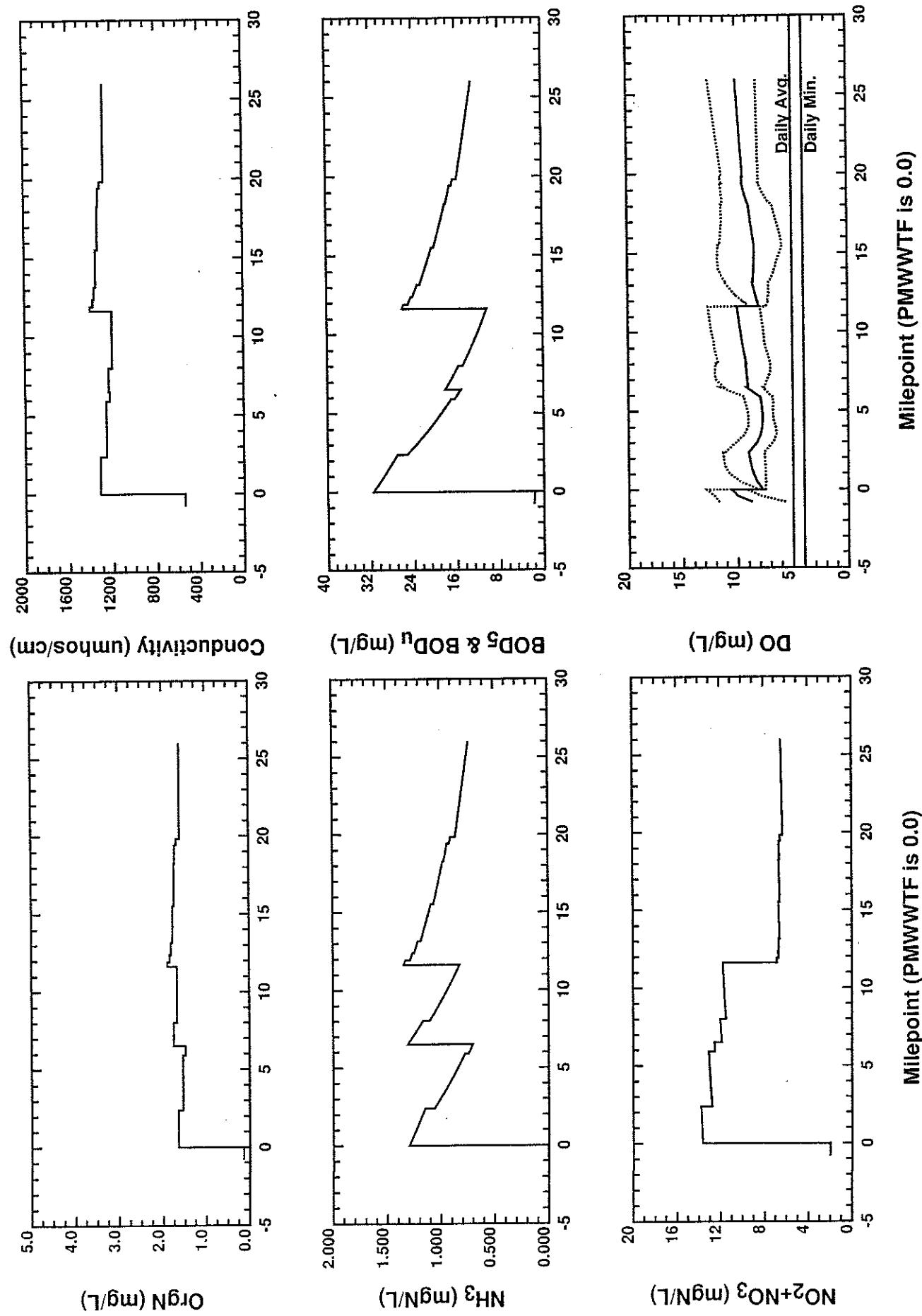
Date	Time	MP	Station ID	DO (mg/L)	DO (% Sat)	Conductivity (umhos/cm)	pH	Temperature (C)
10/13/2004	13:45	-0.221	M1	11.22	105.6	538	8.19	12.60
10/13/2004	14:00	0.190	M2	10.60	101.3	623	8.27	13.20
10/13/2004	14:50	1.141	M3	11.14	106.7	653	8.17	13.30
10/13/2004	15:30	1.803	M4	10.78	103.3	653	8.32	13.40
10/13/2004	16:00	3.015	M5	10.88	104.4	670	8.32	13.40
10/13/2004	16:45	4.022	M6	10.87	103.1	603	8.38	12.90
10/13/2004	17:15	5.408	M7	10.94	103.7	606	8.45	12.90
10/13/2004	14:05	7.081	M8	11.88	110.5	660	7.95	12.08
10/13/2004	16:20		T1	10.39	99.5	550	8.17	13.30
10/13/2004	17:00		T2	11.82	110.2	512	8.37	12.10
10/13/2004	16:45	4.022	M6 Dup	10.87	103.1	603	8.38	12.90
10/13/2004	14:15	8.019	M9	11.45	106.7	659	8.28	12.16
10/13/2004	14:30	9.587	M10	12.46	116.0	657	8.37	12.22
10/13/2004	17:55	11.291	M11	10.50	98.7	651	8.51	12.48
10/13/2004	16:50	11.705	M12	10.61	105.0	773	8.37	14.75
10/13/2004	16:00	12.973	M13	11.12	108.3	699	8.30	14.06
10/13/2004	13:56		T3	10.94	98.8	583	7.90	10.81
10/13/2004	15:05		T4	10.84	105.0	653	8.27	13.89
10/13/2004	16:25		T5	9.70	92.9	638	8.19	13.36
10/13/2004	15:45		T6	8.15	77.1	604	7.79	12.85
10/13/2004	14:45	14.792	M14	12.19	116.8	686	7.81	13.27
10/13/2004	15:22	17.113	M15	11.74	111.2	670	7.76	12.79
10/13/2004	15:42	19.581	M16	11.45	108.0	662	7.80	12.63
10/13/2004	16:04	21.036	M17	11.40	107.4	660	7.71	12.63
10/13/2004	16:44	24.019	M18	11.11	104.5	658	7.84	12.62
10/13/2004	15:07		T7	10.78	100.6	526	7.80	12.18
10/13/2004	16:00	12.973	M13 FDup	11.12	108.3	699	8.30	14.06
10/13/2004	16:05	17.113	M15 FDup	11.12	108.3	699	8.30	14.06
10/13/2004			PMWWTF					
10/13/2004	14:25		OWRF					
10/14/2004	9:15	-0.221	M1	10.27	96.9	551	8.16	13.70
10/14/2004	9:50	0.190	M2	10.30	99.2	684	8.22	13.60
10/14/2004	10:20	1.141	M3	9.83	94.2	681	8.22	13.40
10/14/2004	10:50	1.803	M4	9.85	94.5	679	8.27	13.40
10/14/2004	11:45	3.015	M5	10.27	98.2	614	8.27	13.30
10/14/2004	12:30	4.022	M6	10.46	100.5	643	8.28	13.50
10/14/2004	12:30	4.022	M6 Fdup	10.46	100.5	643	8.28	13.50
10/14/2004	13:00	5.408	M7	10.69	103.2	641	8.38	13.80
10/14/2004	9:20	7.081	M8	9.71	91.5	651	7.84	12.52
10/14/2004	12:05		T1	10.34	98.0	553	8.14	12.90
10/14/2004	13:20		T2	13.69	131.5	501	8.49	13.50
10/14/2004	11:00	8.019	M9	10.21	96.9	650	8.30	12.81
10/14/2004	10:40	9.587	M10	11.04	104.4	658	8.36	12.77
10/14/2004	13:45	11.291	M11	12.50	120.3	634	8.57	13.48
10/14/2004	9:30	11.705	M12	9.54	94.2	756	8.23	14.63
10/14/2004	9:15	12.973	M13	9.56	91.7	692	8.15	13.40
10/14/2004	9:20	12.973	M13 FDup	9.56	91.7	692	8.15	13.40
10/14/2004	11:15		T3	9.31	86.6	645	8.13	11.98
10/14/2004	10:15		T4	10.34	99.7	640	8.19	13.72
10/14/2004	10:00		T5	9.88	93.4	643	8.19	12.84
10/14/2004	8:55		T6	7.66	72.4	601	7.88	12.76
10/14/2004	9:40	14.792	M14	10.08	95.7	671	7.72	13.12
10/14/2004	10:07	17.113	M15	9.66	92.4	667	7.72	13.17
10/14/2004	10:33	19.581	M16	9.67	92.4	664	7.79	13.19
10/14/2004	10:50	21.036	M17	9.89	94.3	656	7.78	13.13
10/14/2004	10:50	21.036	M17 Fdup	9.89	94.3	656	7.78	13.13
10/14/2004	11:20	24.019	M18	9.92	94.4	644	7.85	13.02
10/14/2004	11:49	25.843	M19	9.25	87.8	634	7.75	12.95
10/14/2004	9:53		T7	9.91	93.4	529	7.76	12.58
10/14/2004	14:25		PMWWTF					
10/14/2004			OWRF					

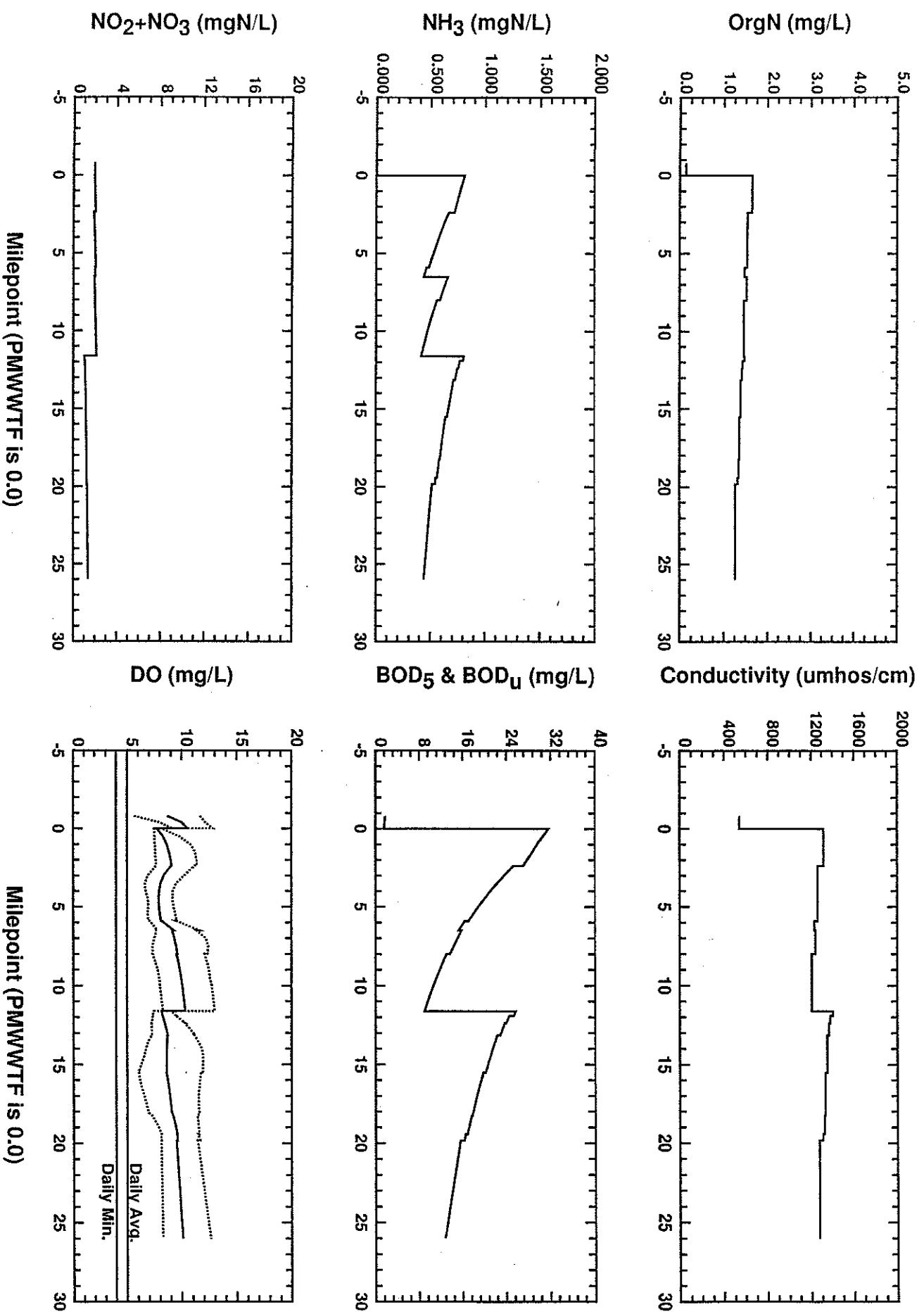
APPENDIX 2

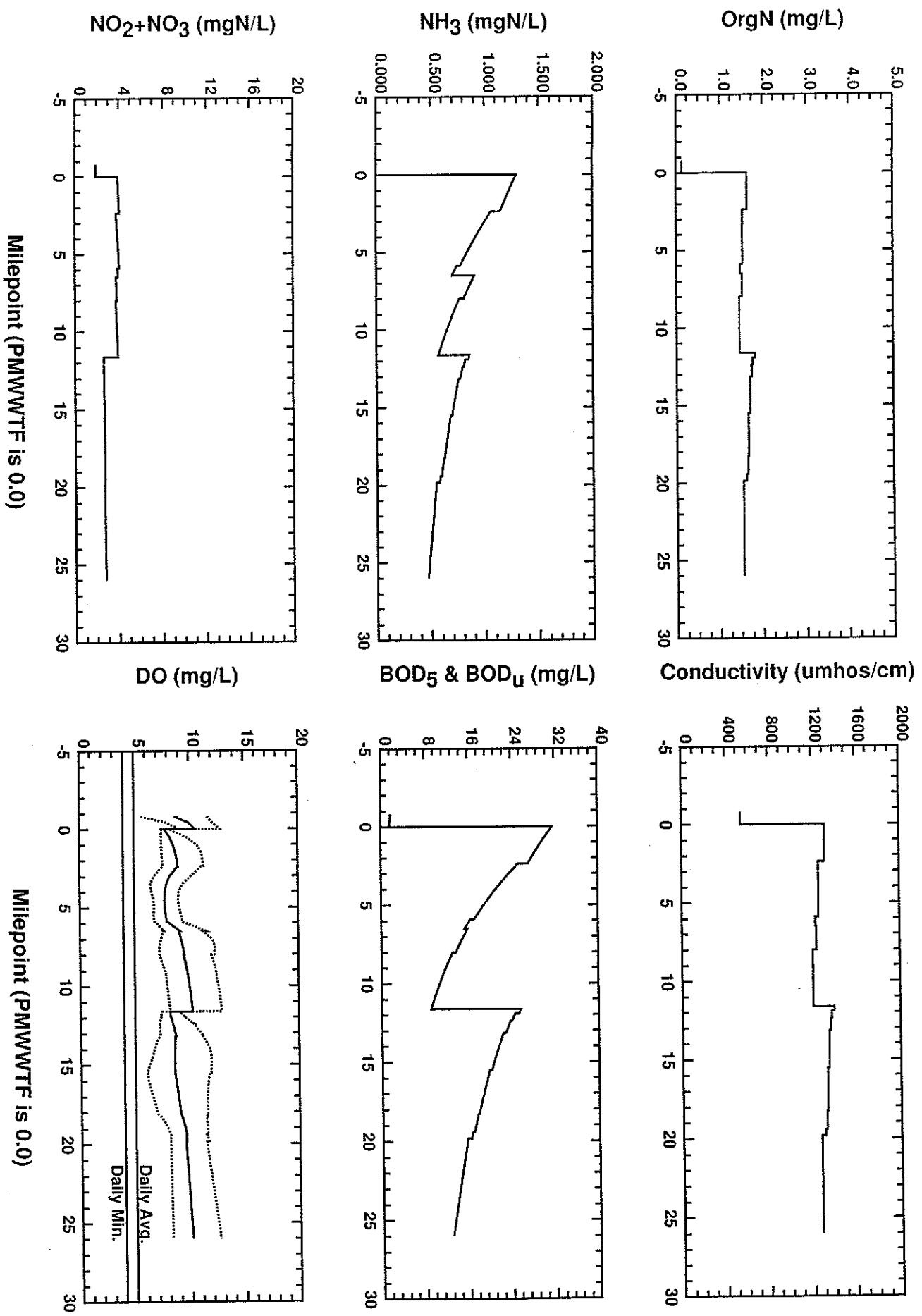
TIER 1, SCENARIOS 1-5 CLOUDY CONDITIONS

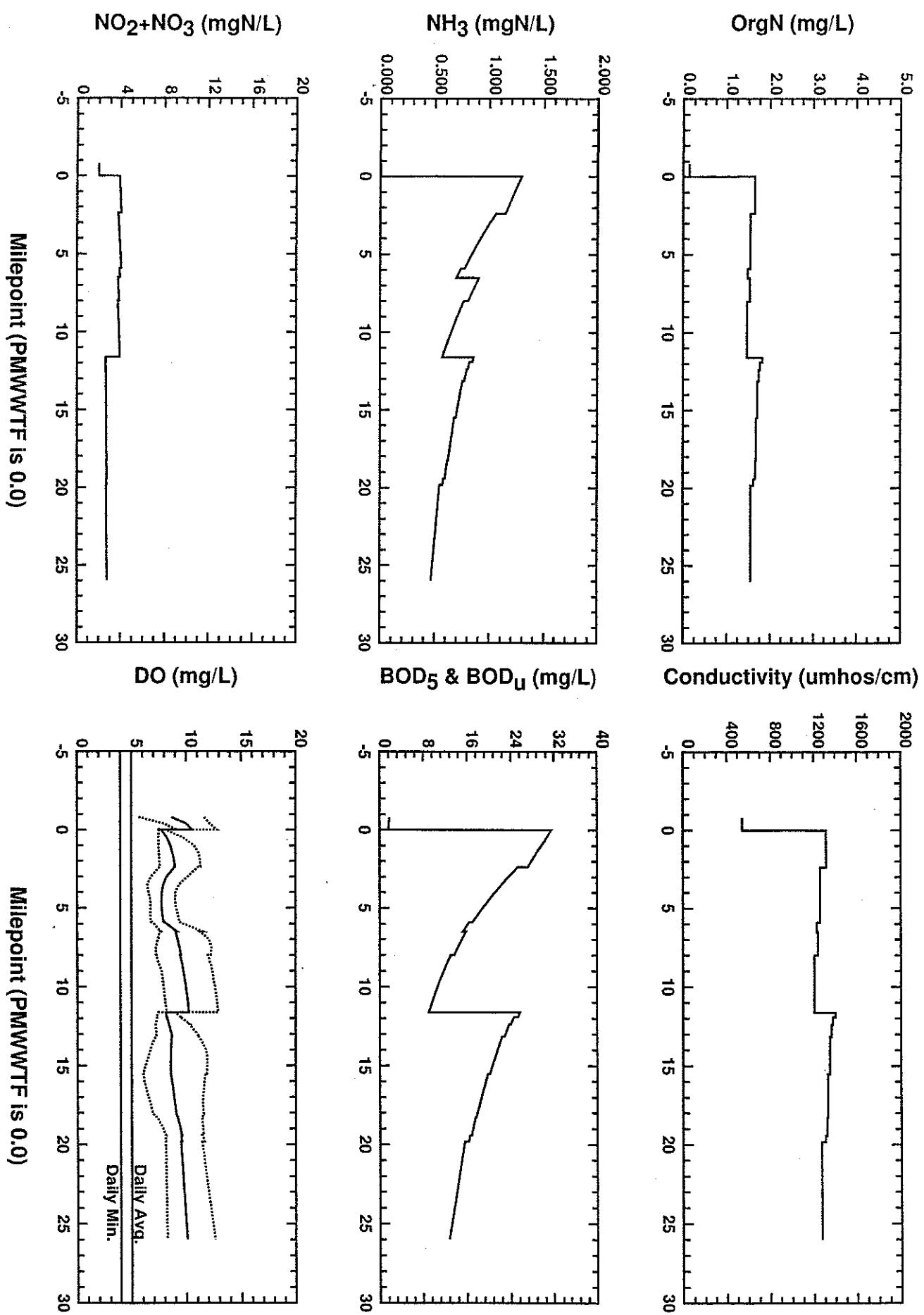


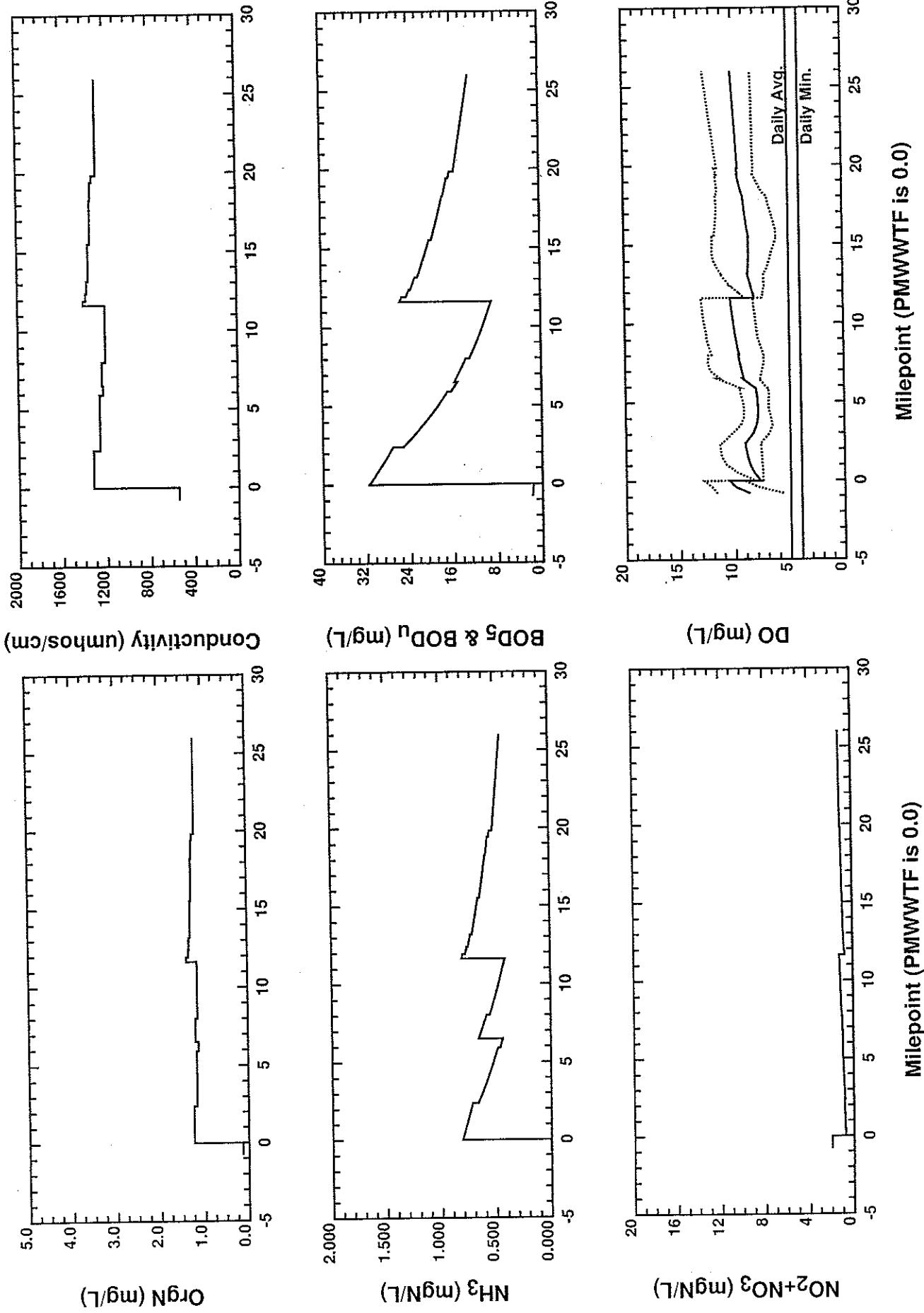
Environmental
Engineers & Scientists











Tier 1 - Scenario 5

Figure . Opequon Creek Water Quality Projections - Cloudy Day
/usersim/obag0060/HEIDIMODEL/PROJECTION/TIER1/CLLOUDY/t1s5.gdp

APPENDIX 3

TIER 2, SCENARIOS 1-5 CLOUDY CONDITIONS



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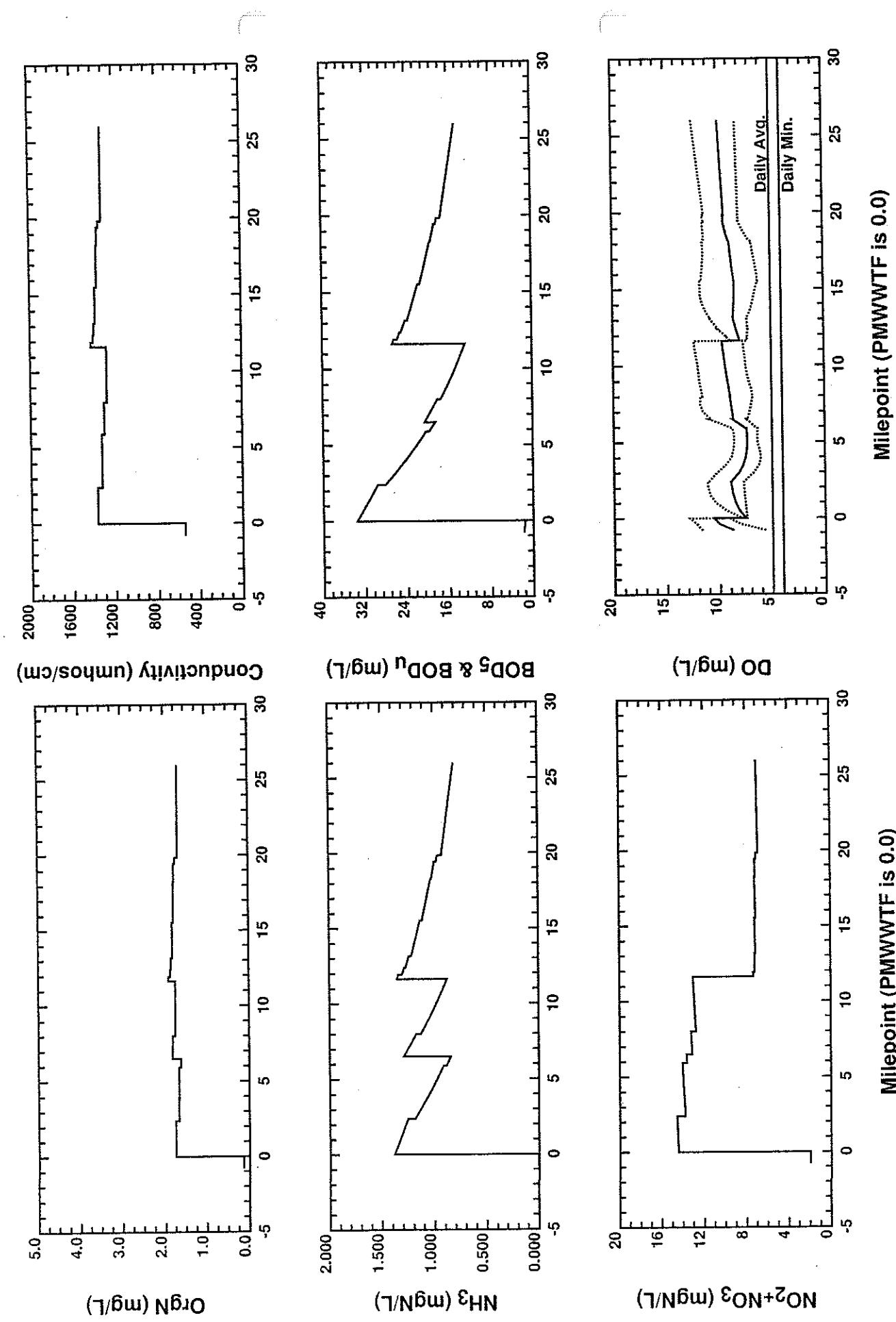
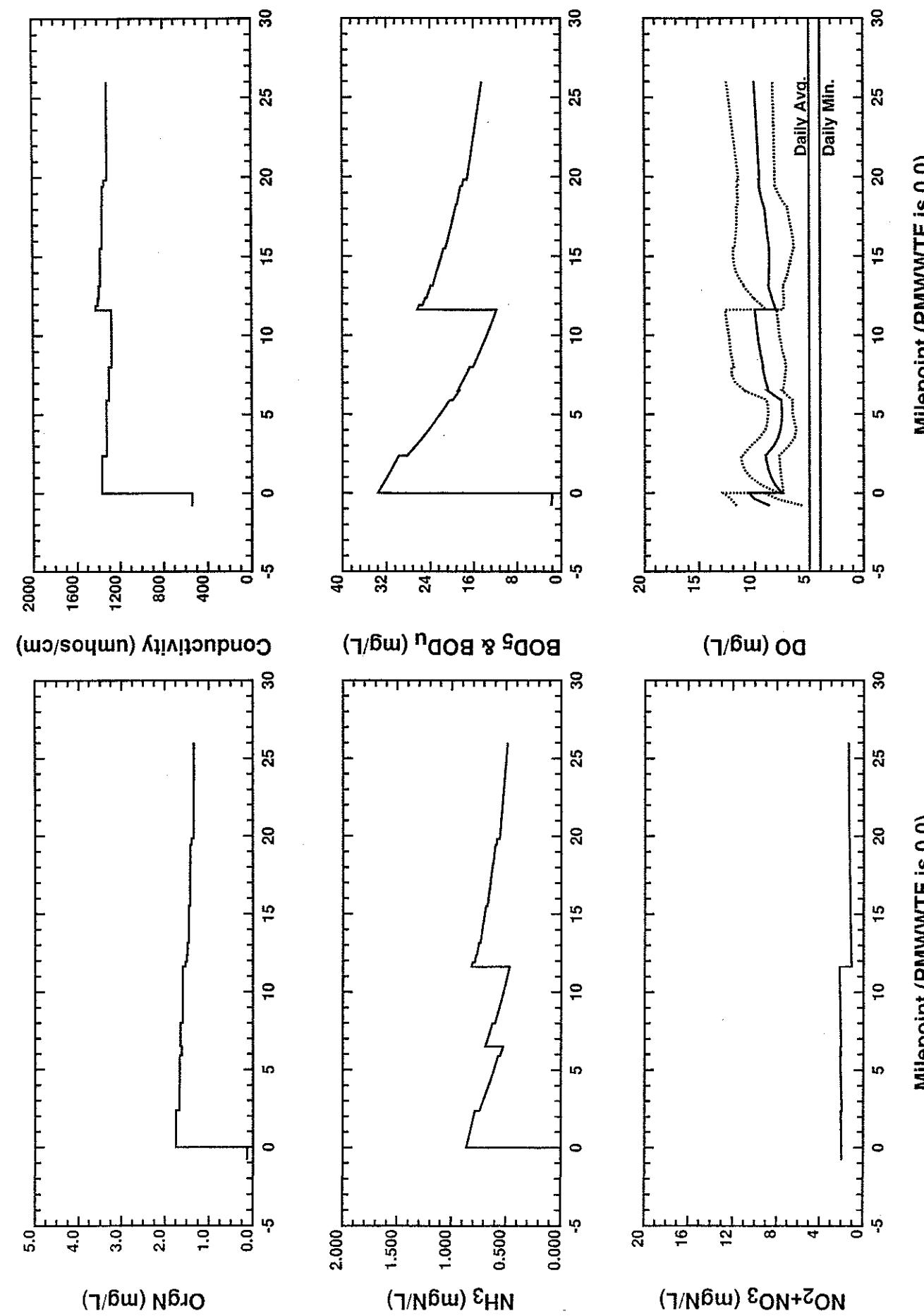
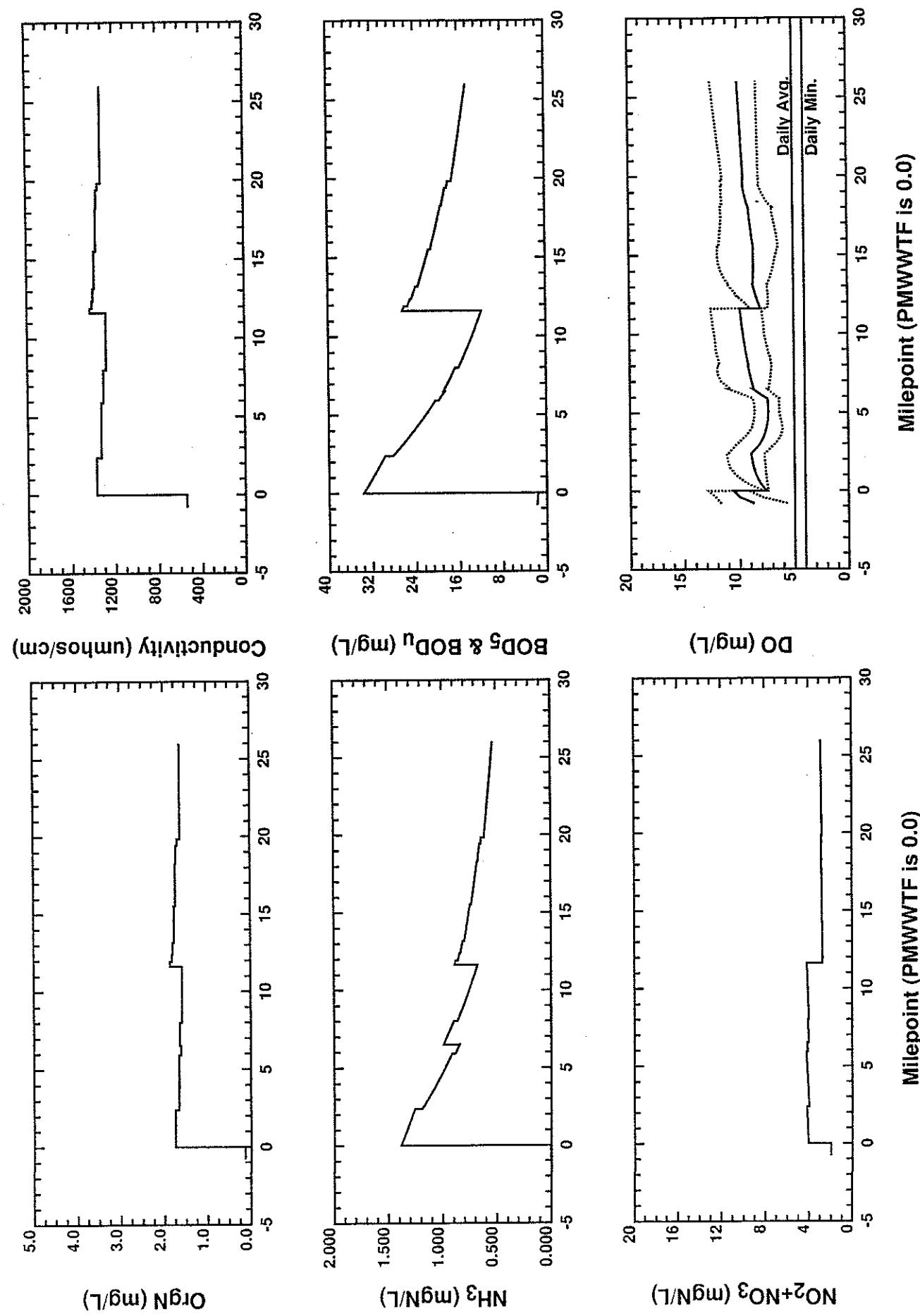


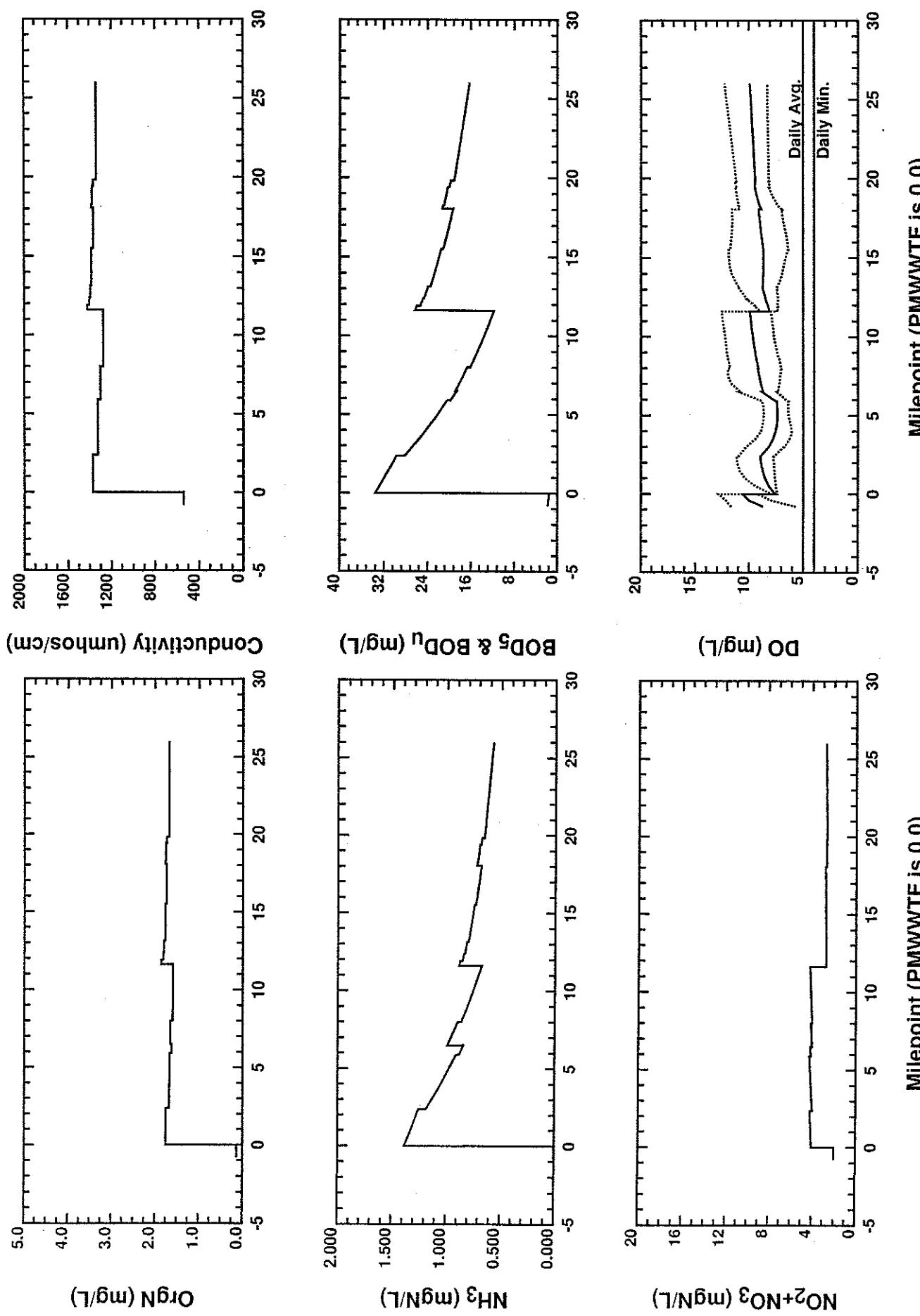
Figure . Opequon Creek Water Quality Projections
/users/miobag0060/HEIDIMODEL/PROJECTION/TIER2/t2s1.gdp

Tier 2 - Scenario 1

DATE: 2/23/2005 TIME: 13:33:43







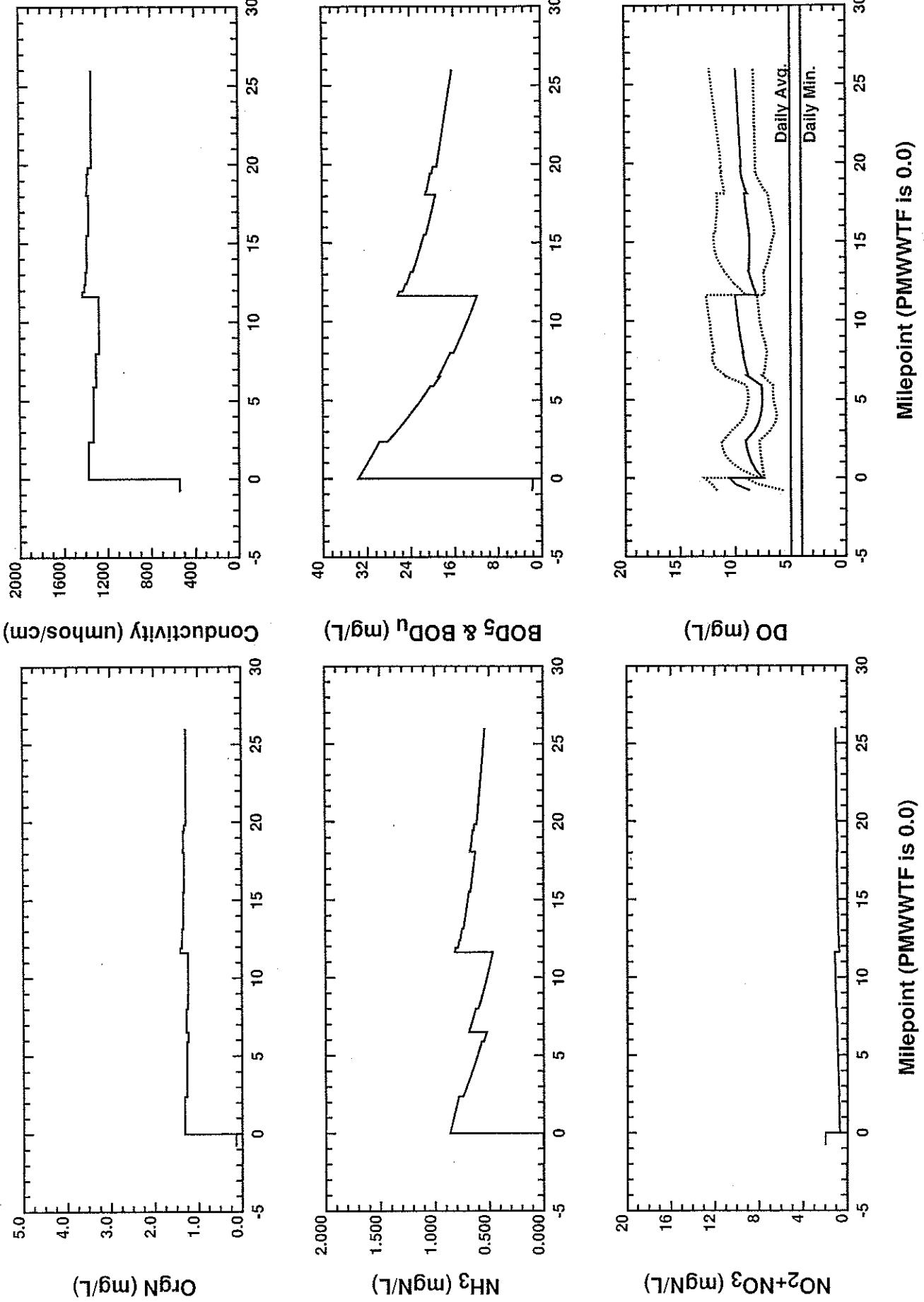


Figure . Opequon Creek Water Quality Projections
 /usersmi/obag0060/HEID/MODEL/PROJECTION/TIER2/t2s5.gdp

Tier 2 - Scenario 5

DATE: 2/23/2005 TIME: 13:33:53

APPENDIX 4

TIER 3, SCENARIOS 1-5 CLOUDY CONDITIONS



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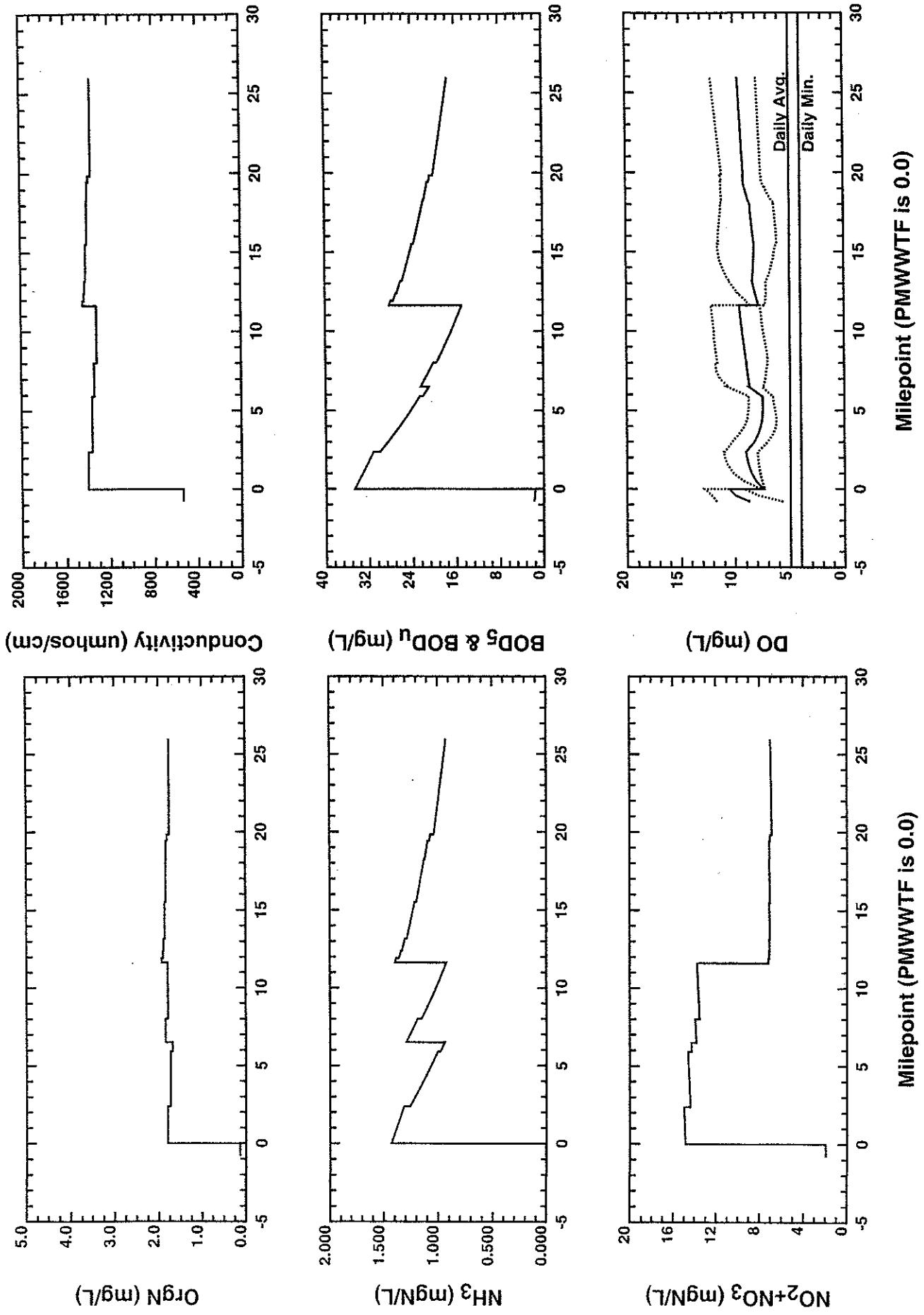


Figure . Opequon Creek Water Quality Projections
/users/m/obag0060/HEIDI/MODEL/PROJECTION/TIER3/t3s1.gdp

Tier 3 - Scenario 1

DATE: 3/14/2005 TIME: 9:24:38

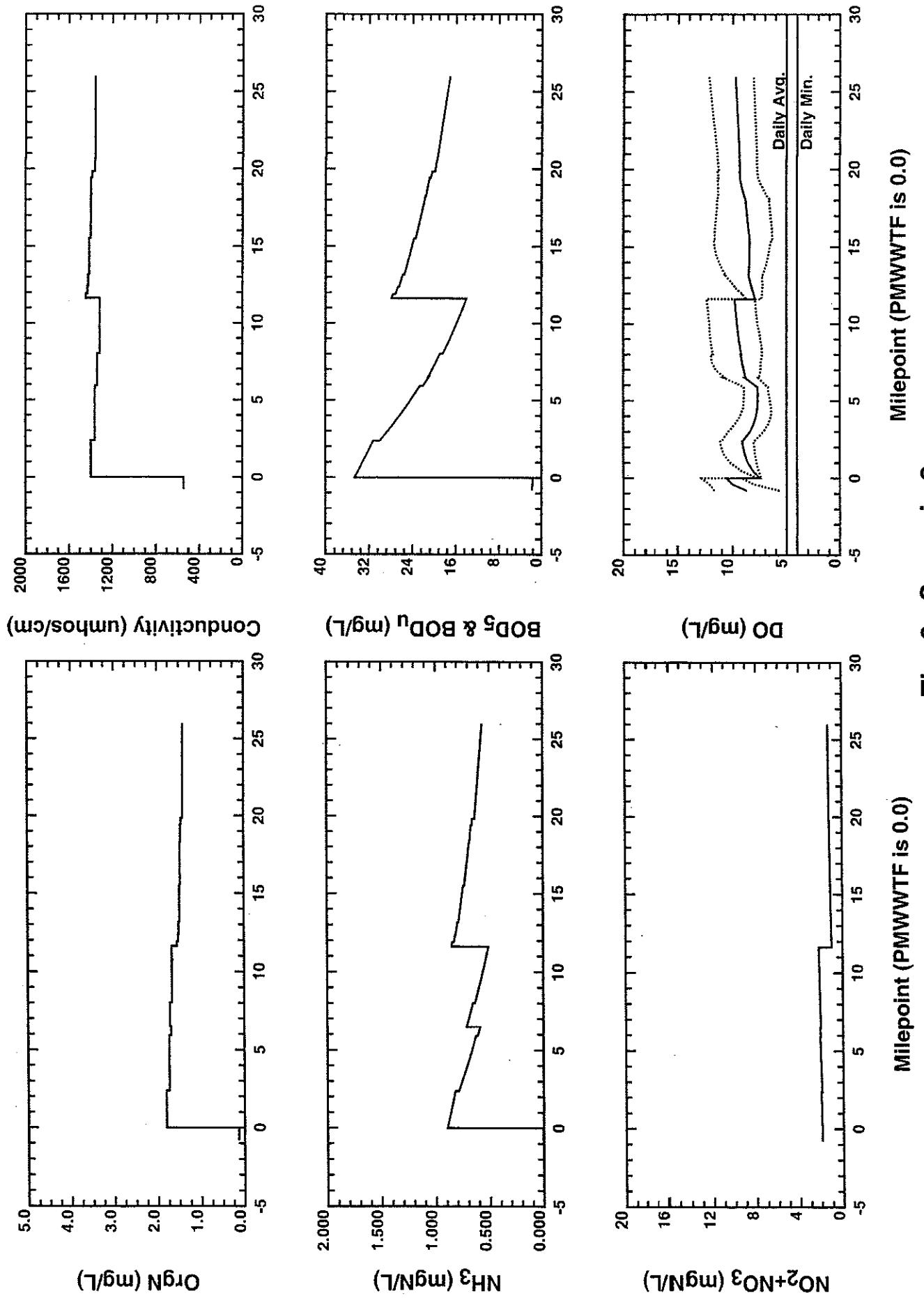


Figure . Opequon Creek Water Quality Projections
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DATE: 3/14/2005 TIME: 9:23:10

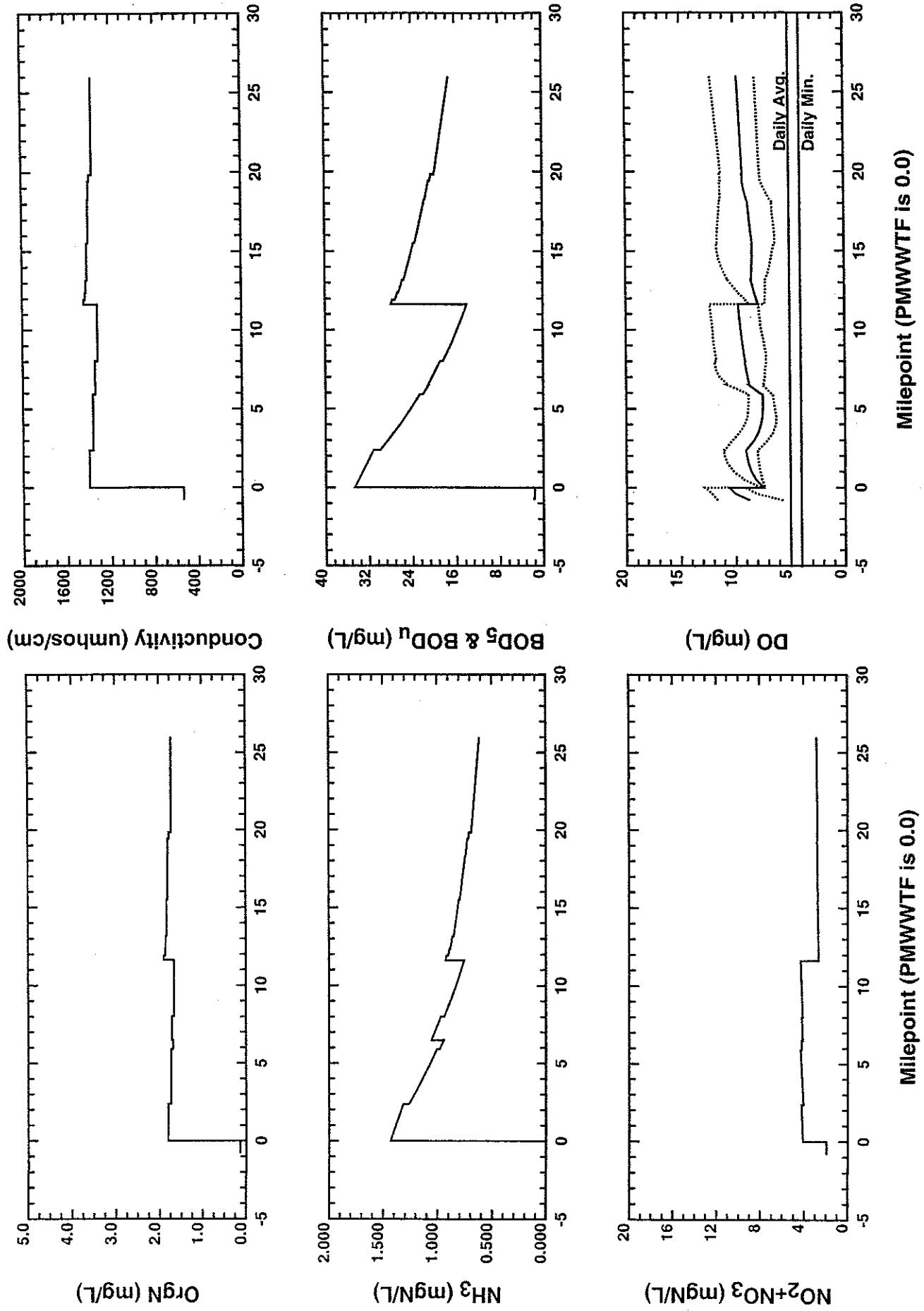
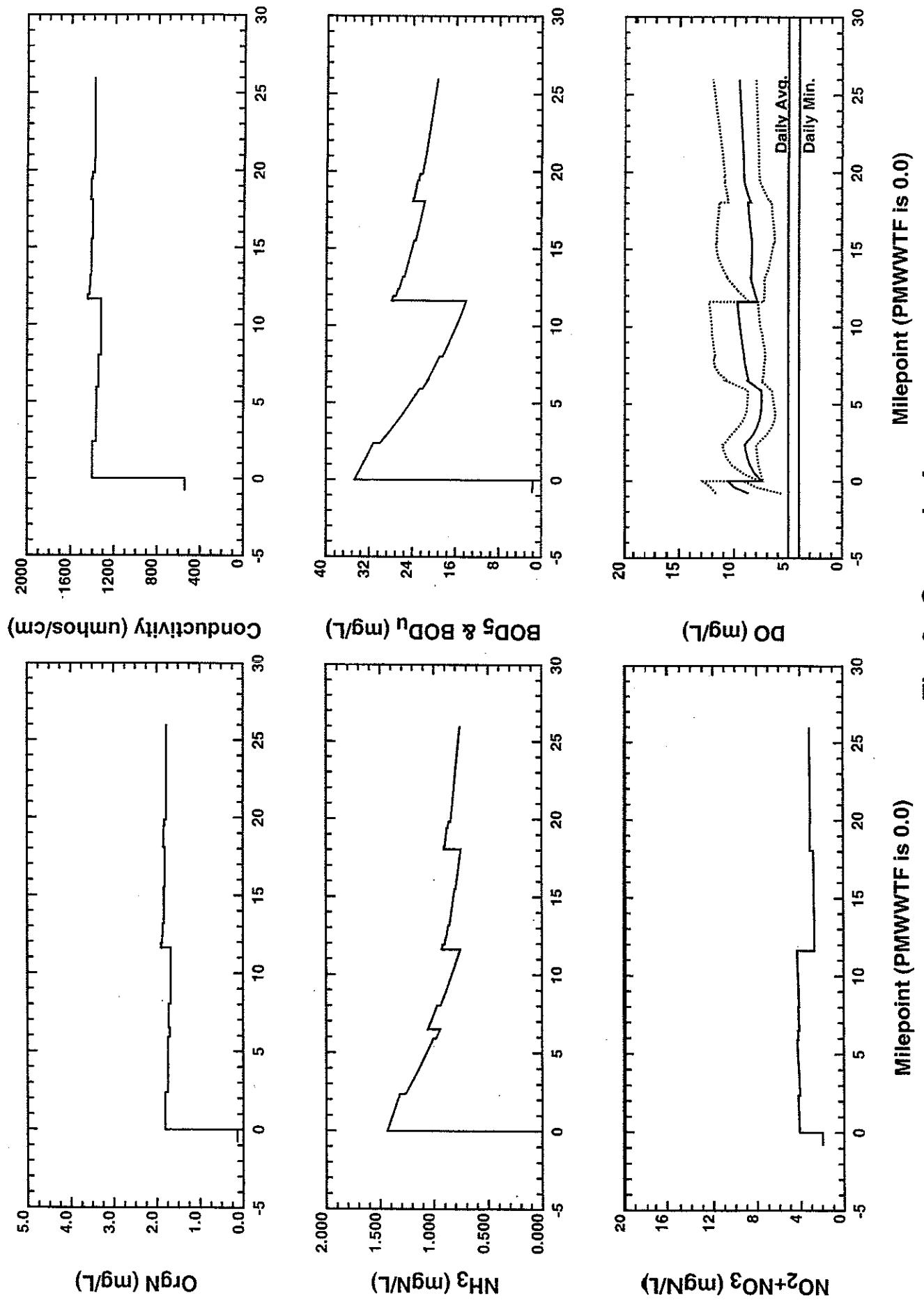


Figure . Opequon Creek Water Quality Projections
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Tier 3 - Scenario 3

DATE: 3/14/2005 TIME: 9:25:12



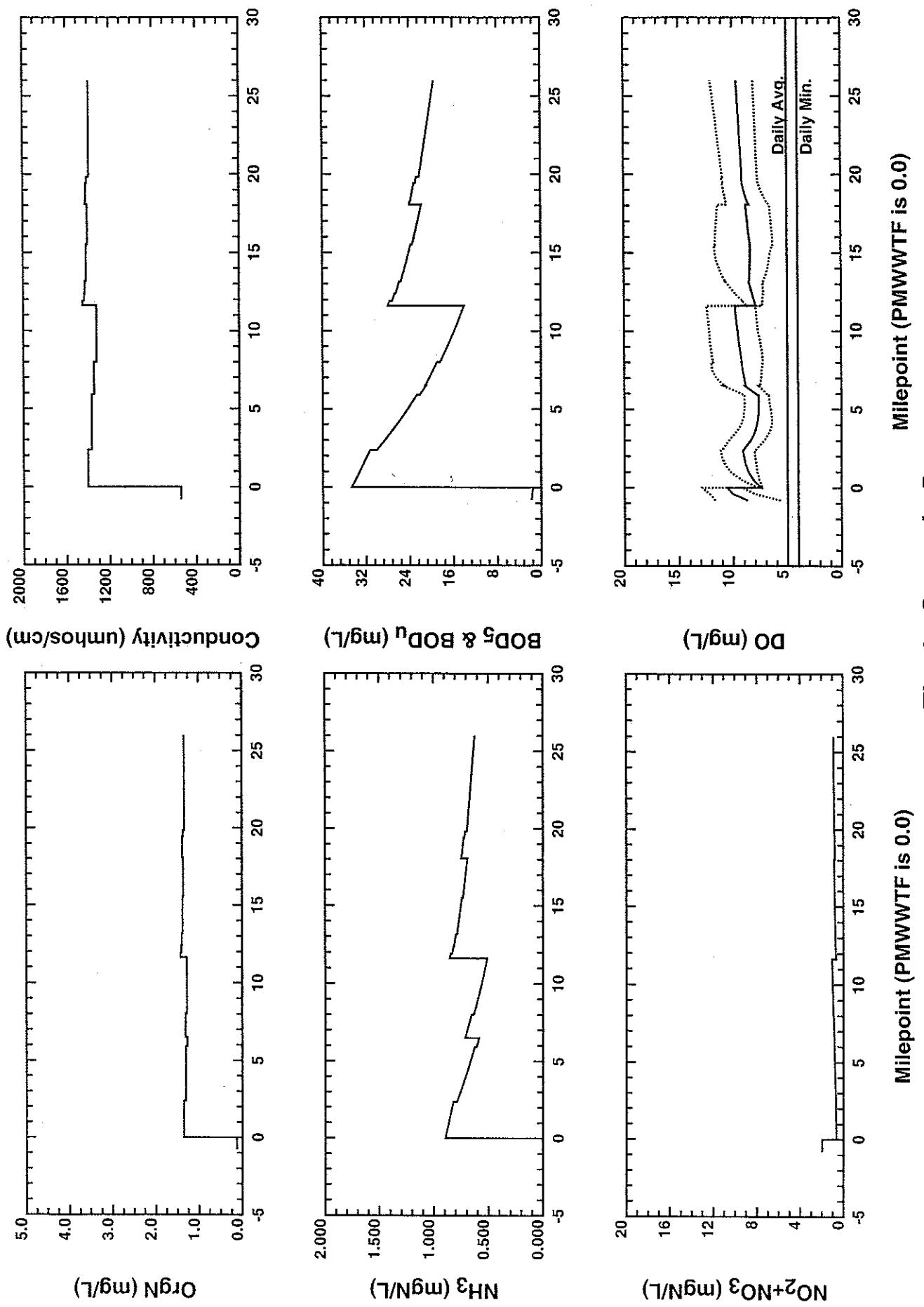
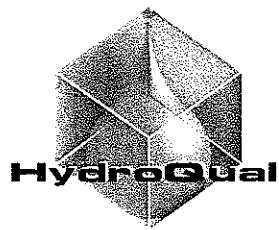


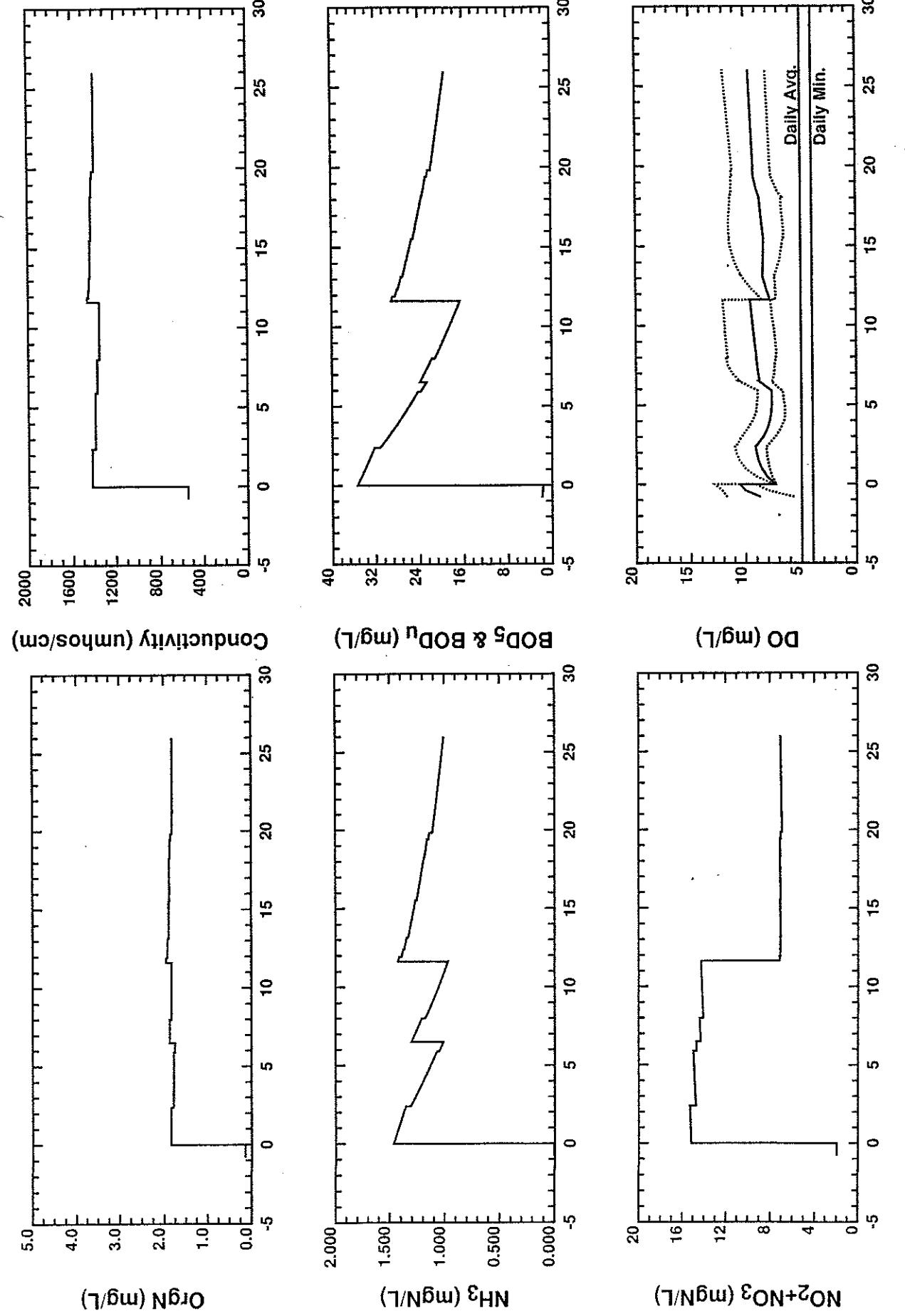
Figure . Opequon Creek Water Quality Projections
Tier 3 - Scenario 5
/usersm/obag0060/HEIDI/MODEL/PROJECTION/TIER3/t3s5.gdp

APPENDIX 5

TIER 4, SCENARIOS 1-5 CLOUDY CONDITIONS



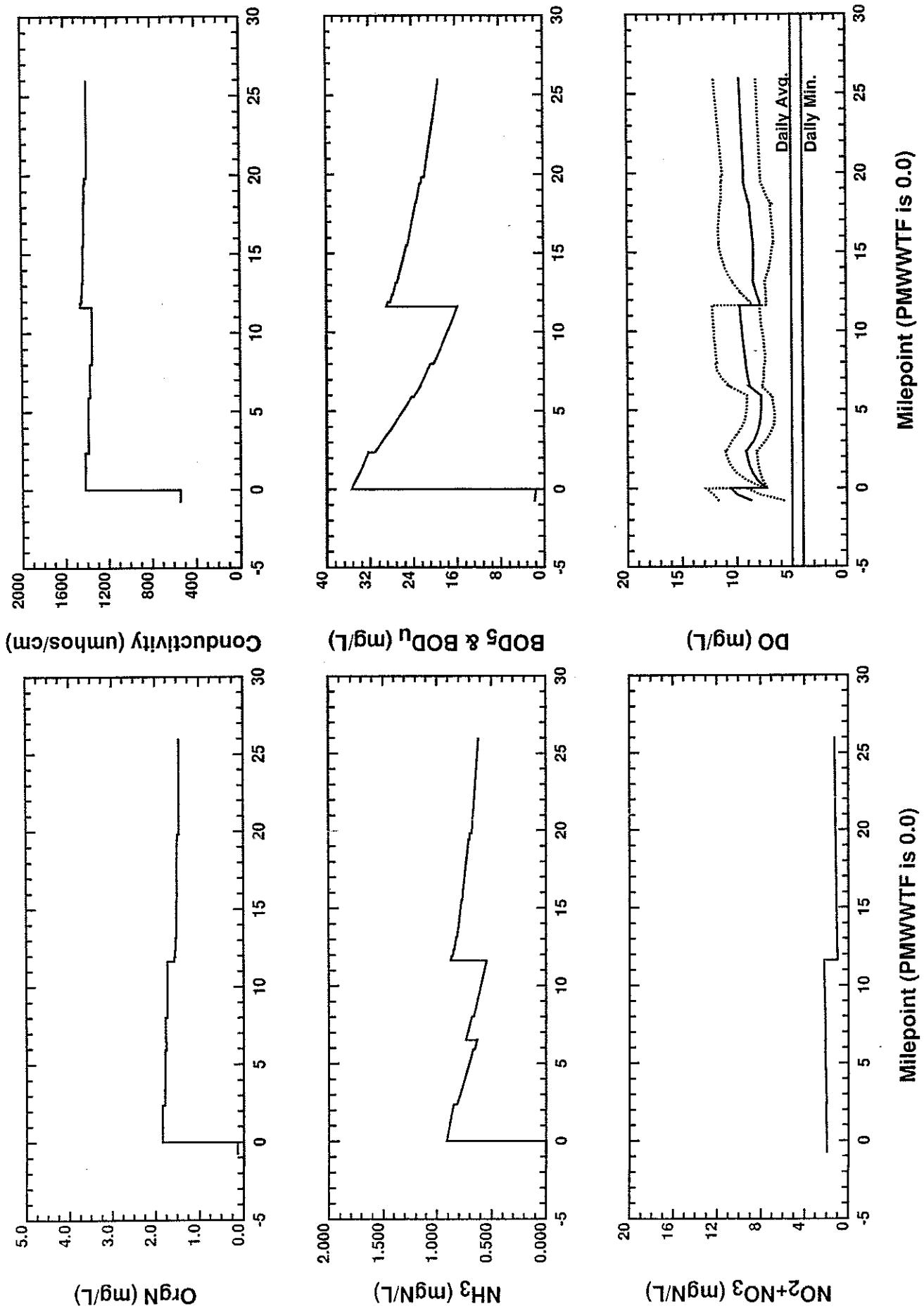
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Engineers & Scientists

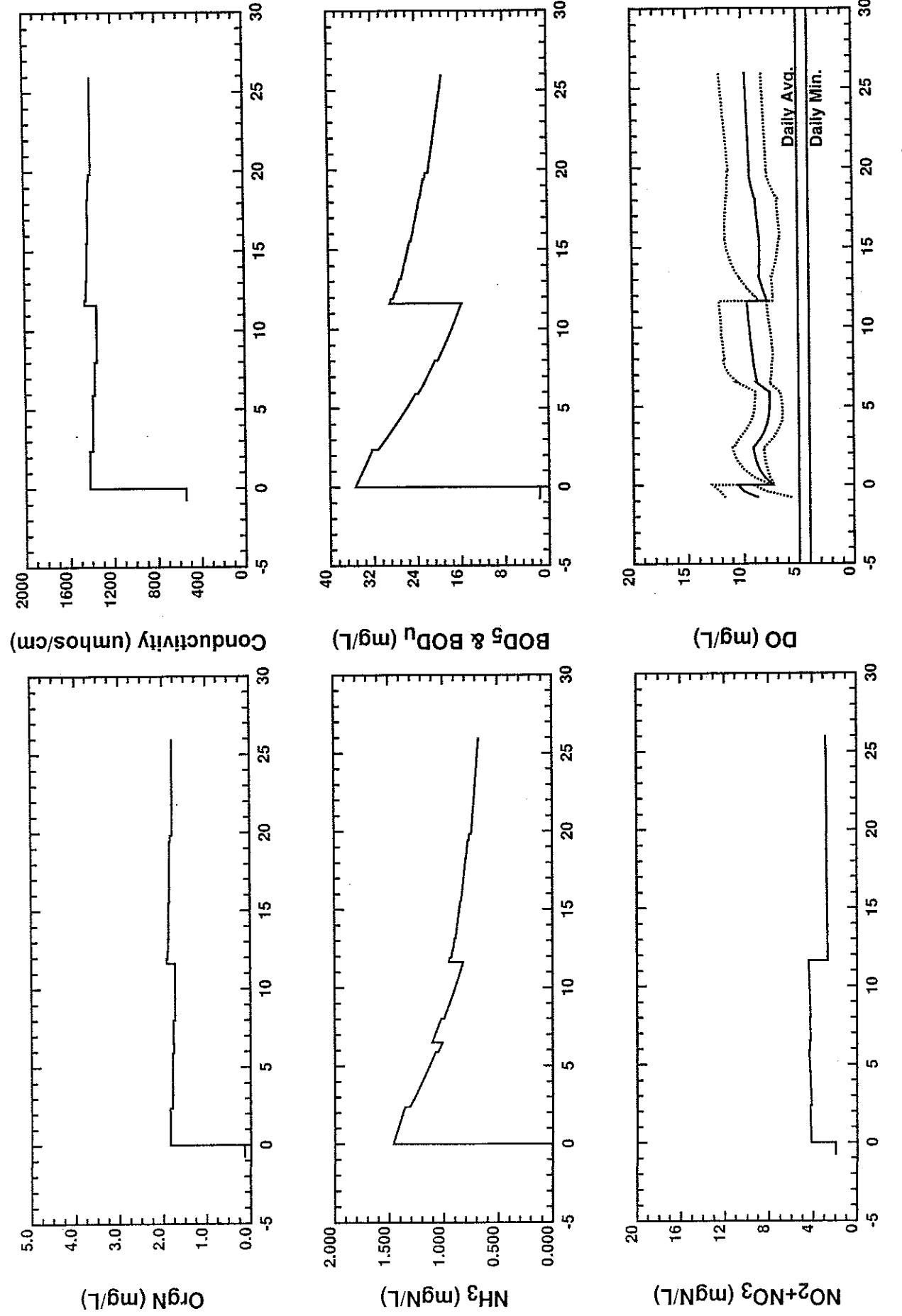


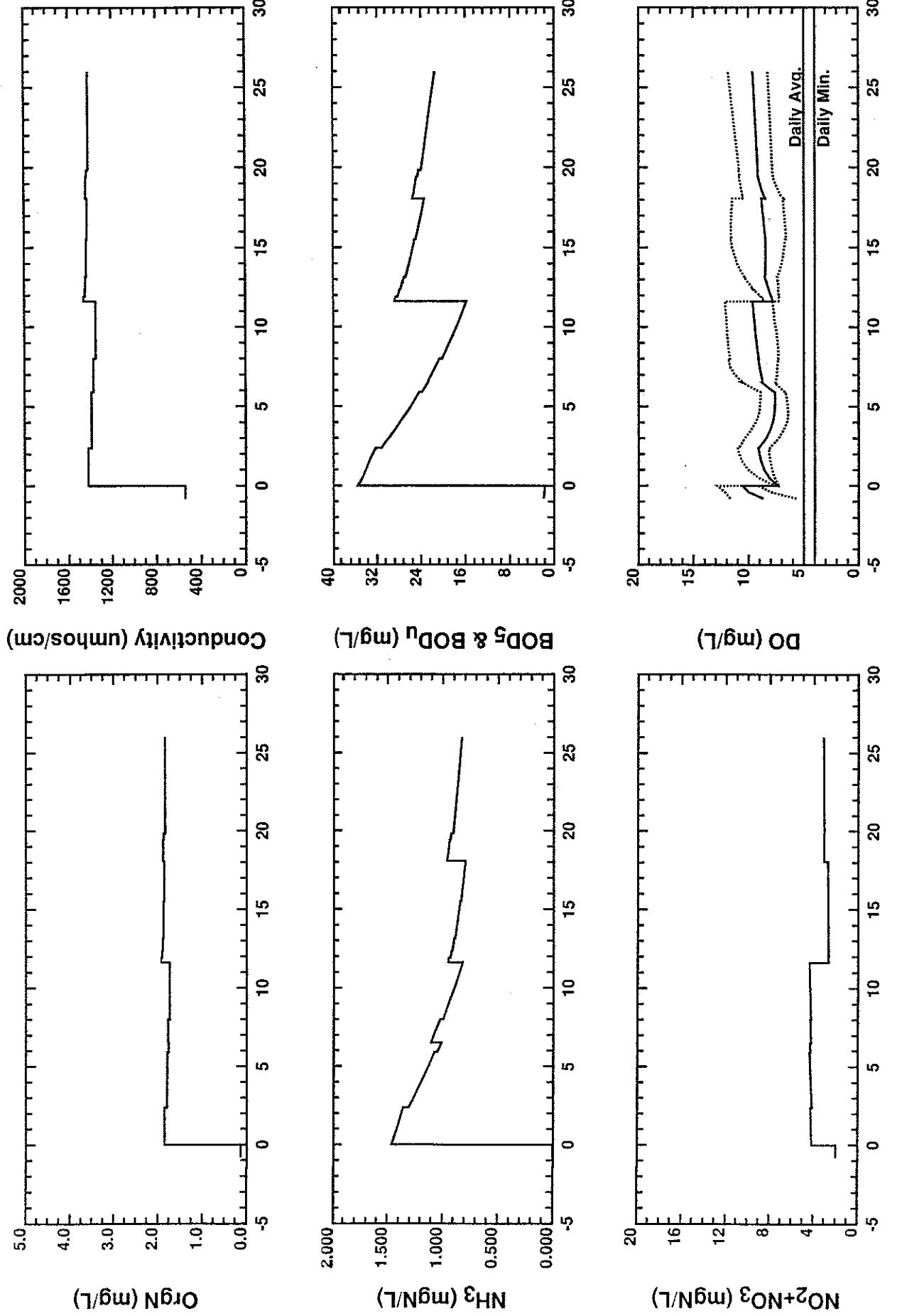
Tier 4 - Scenario 1 - Cloudy Day

Figure . Opequon Creek Water Quality Projections

DATE: 2/23/2005 TIME: 15:40:36



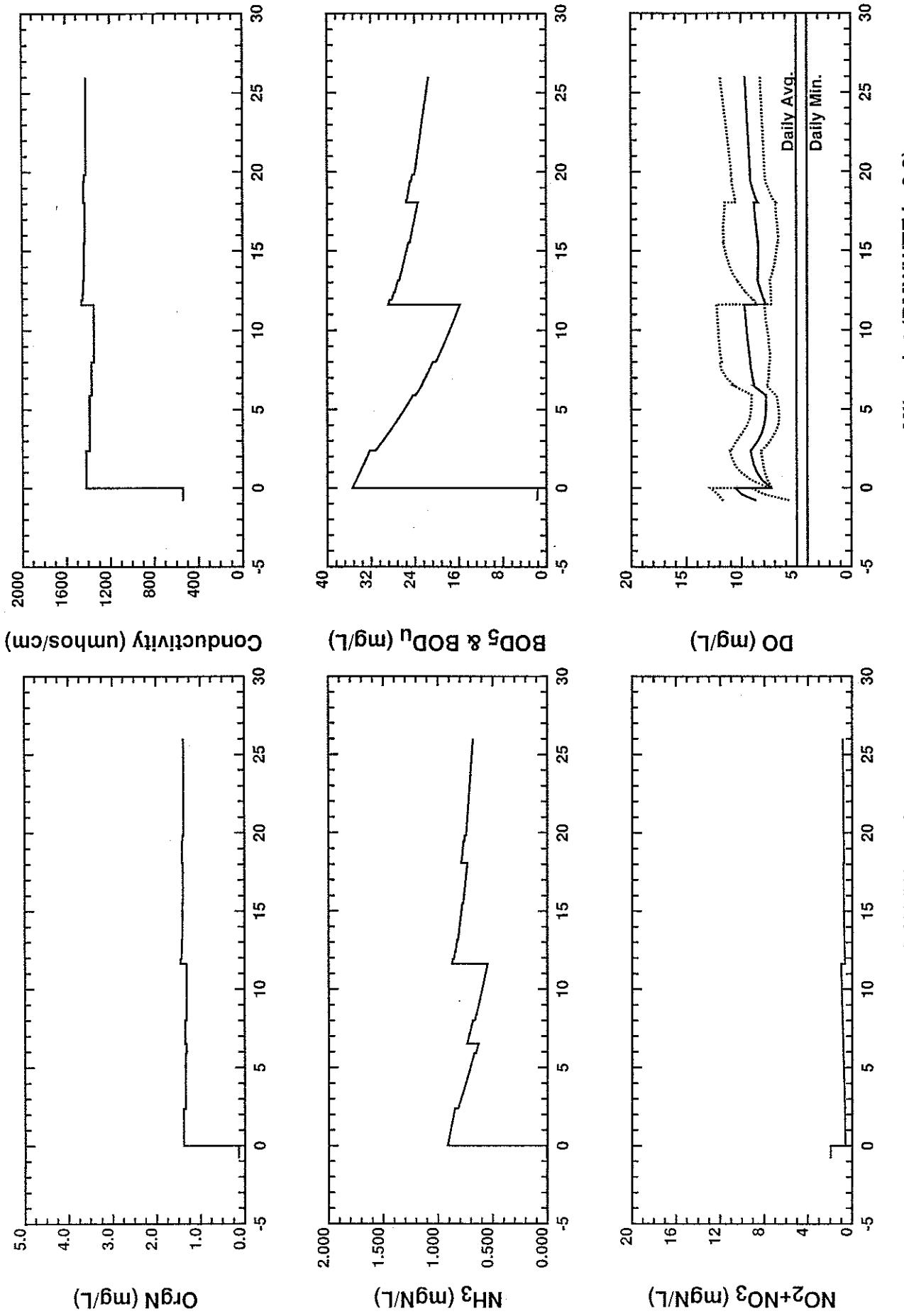




Milepoint (PMWWTF is 0.0)

Tier 4 - Scenario 4 - Cloudy Day

Figure . Opequon Creek Water Quality Projections

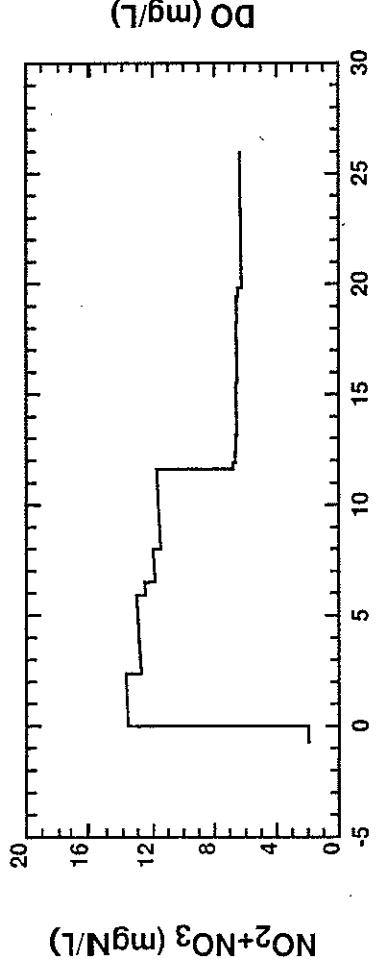
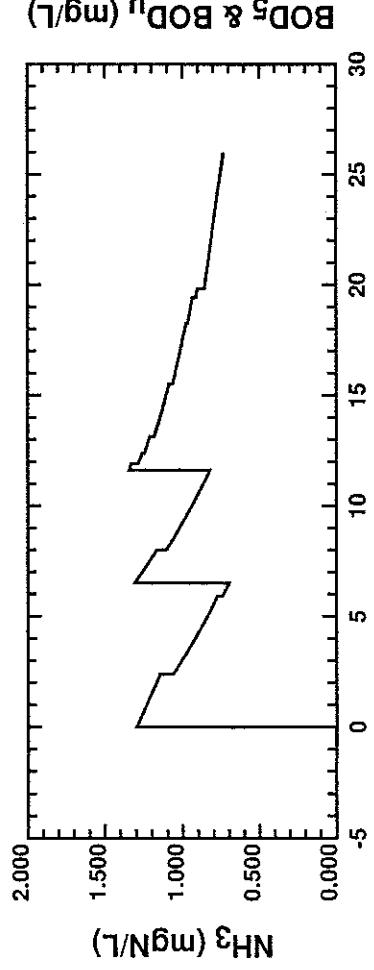
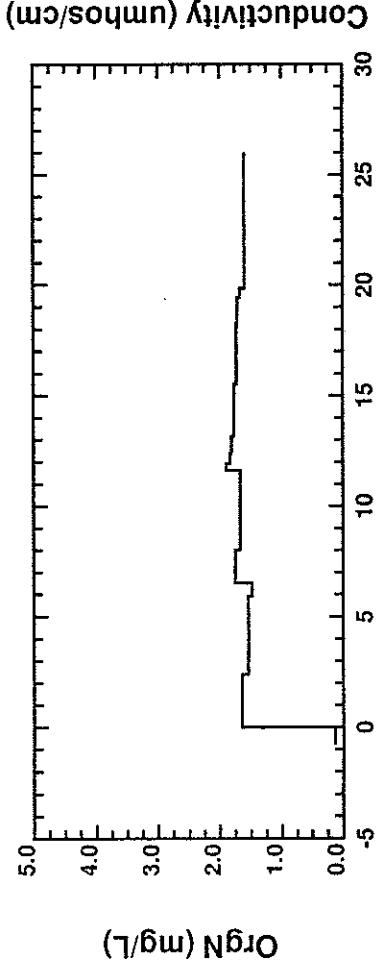
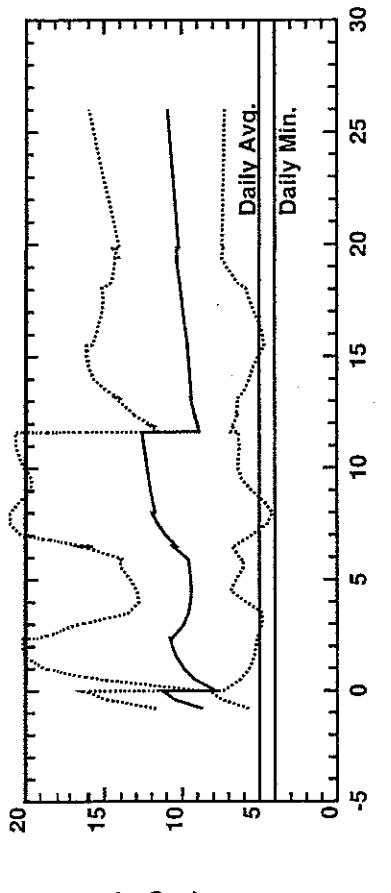
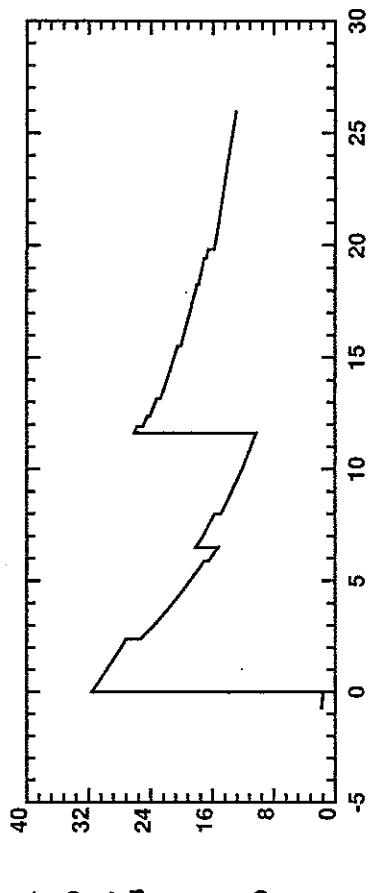
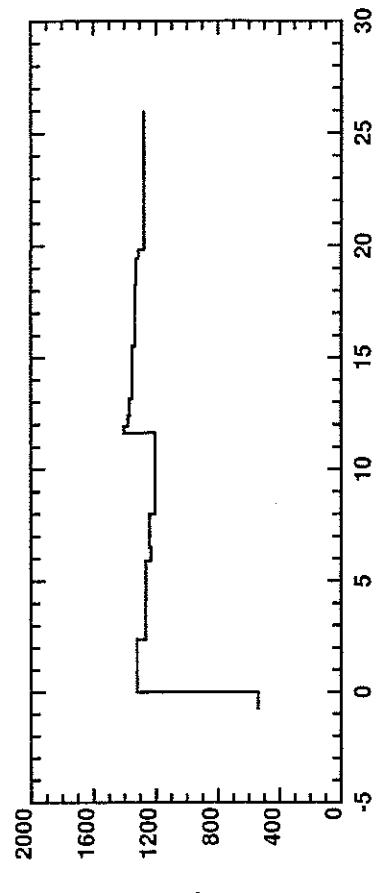


APPENDIX 6

TIER 1, SCENARIOS 1-5 SUNNY CONDITIONS

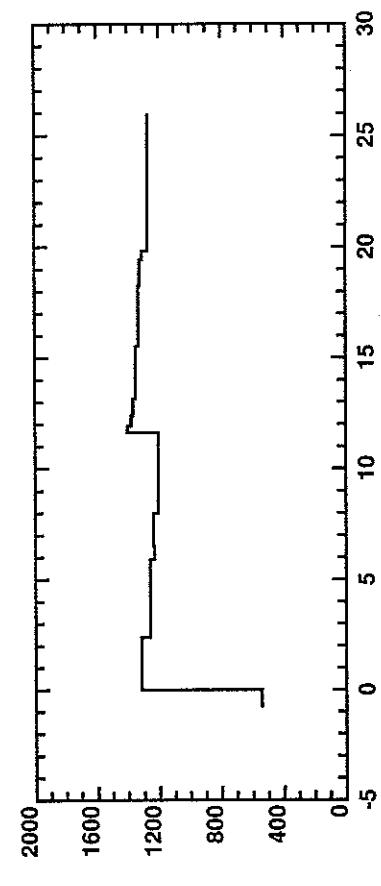


Environmental
Engineers & Scientists

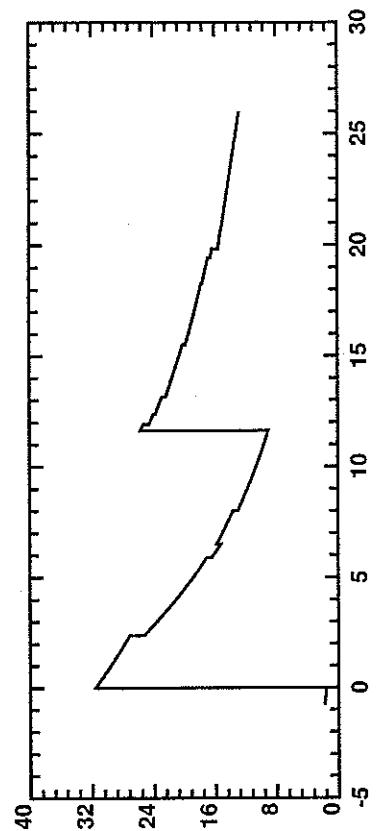


Milepoint (PMWWTF is 0.0)

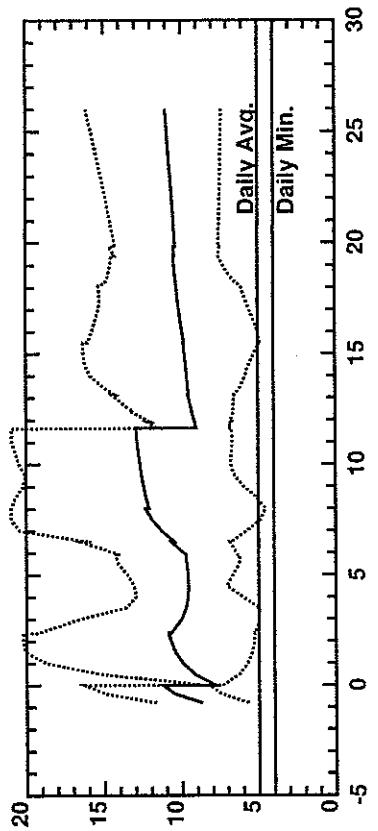
**Figure : Opequon Creek Water Quality Projections Tier 1 - Scenario 1
Change : Pmax in seg 4 and 5**



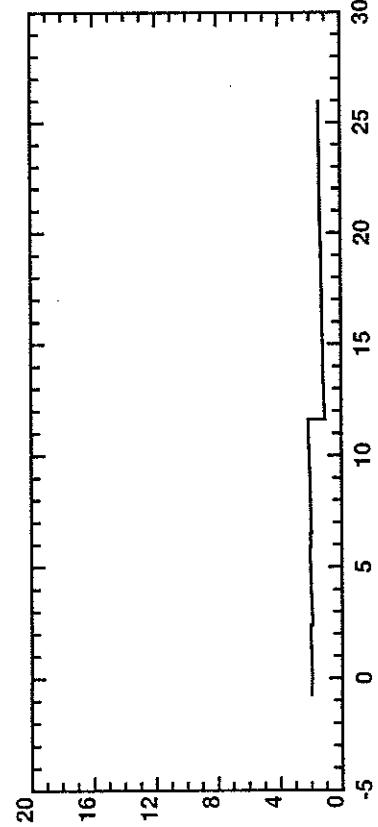
Conductivity (umhos/cm)



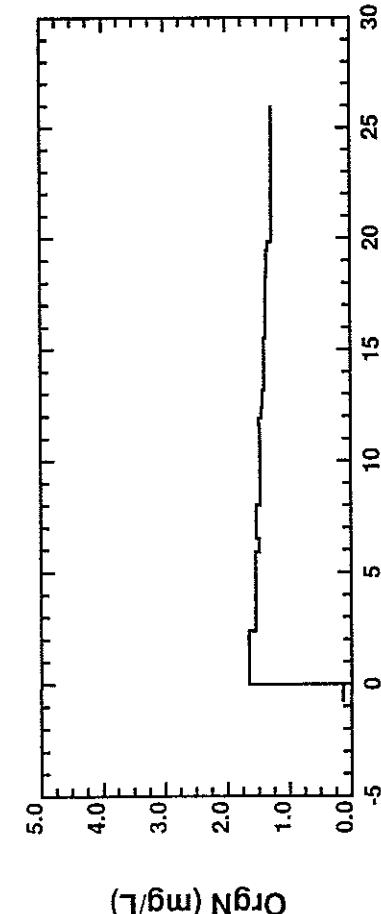
BOD₅ & BOD_u (mg/L)



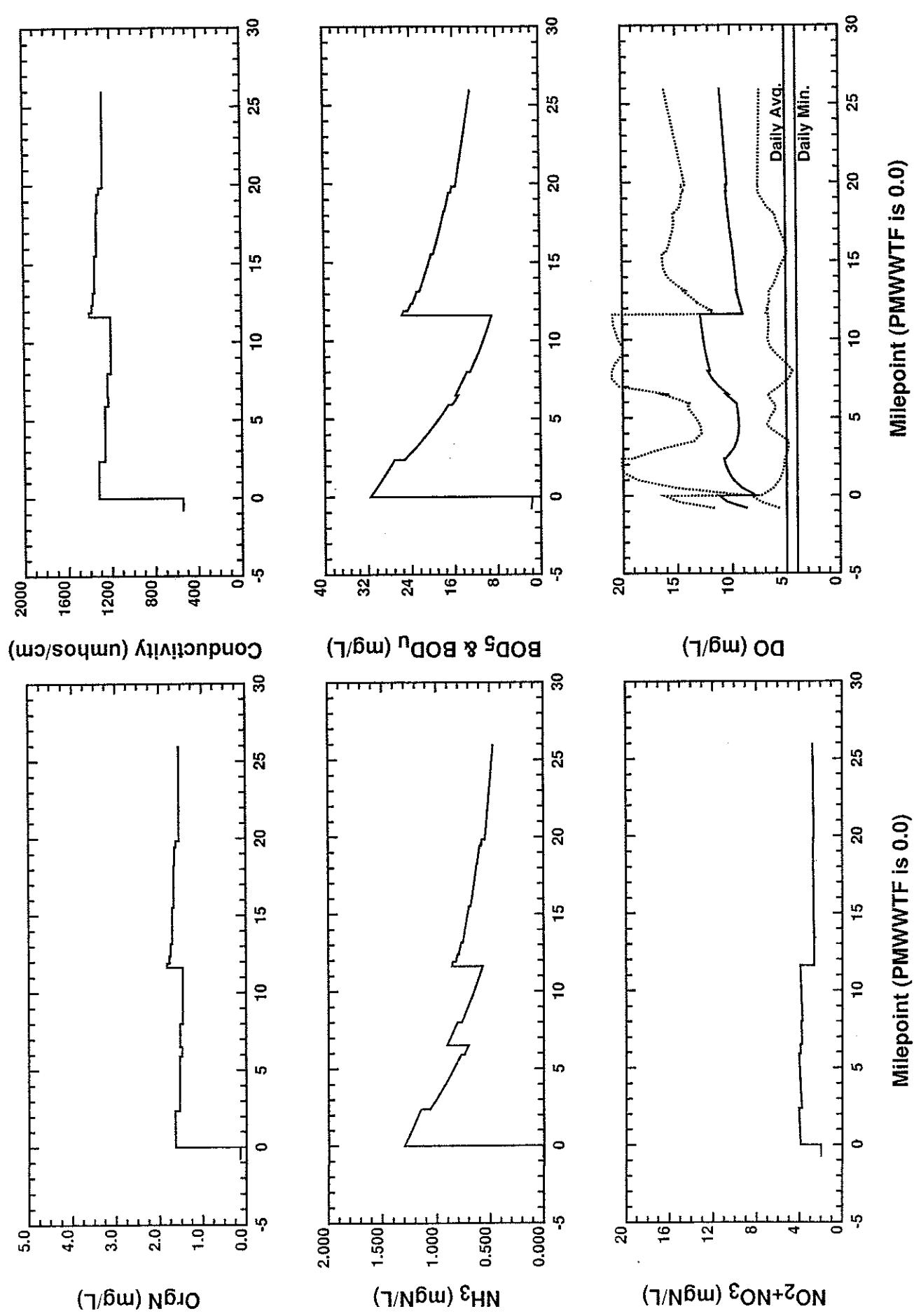
DO (mg/L)



NO₂+NO₃ (mgN/L)



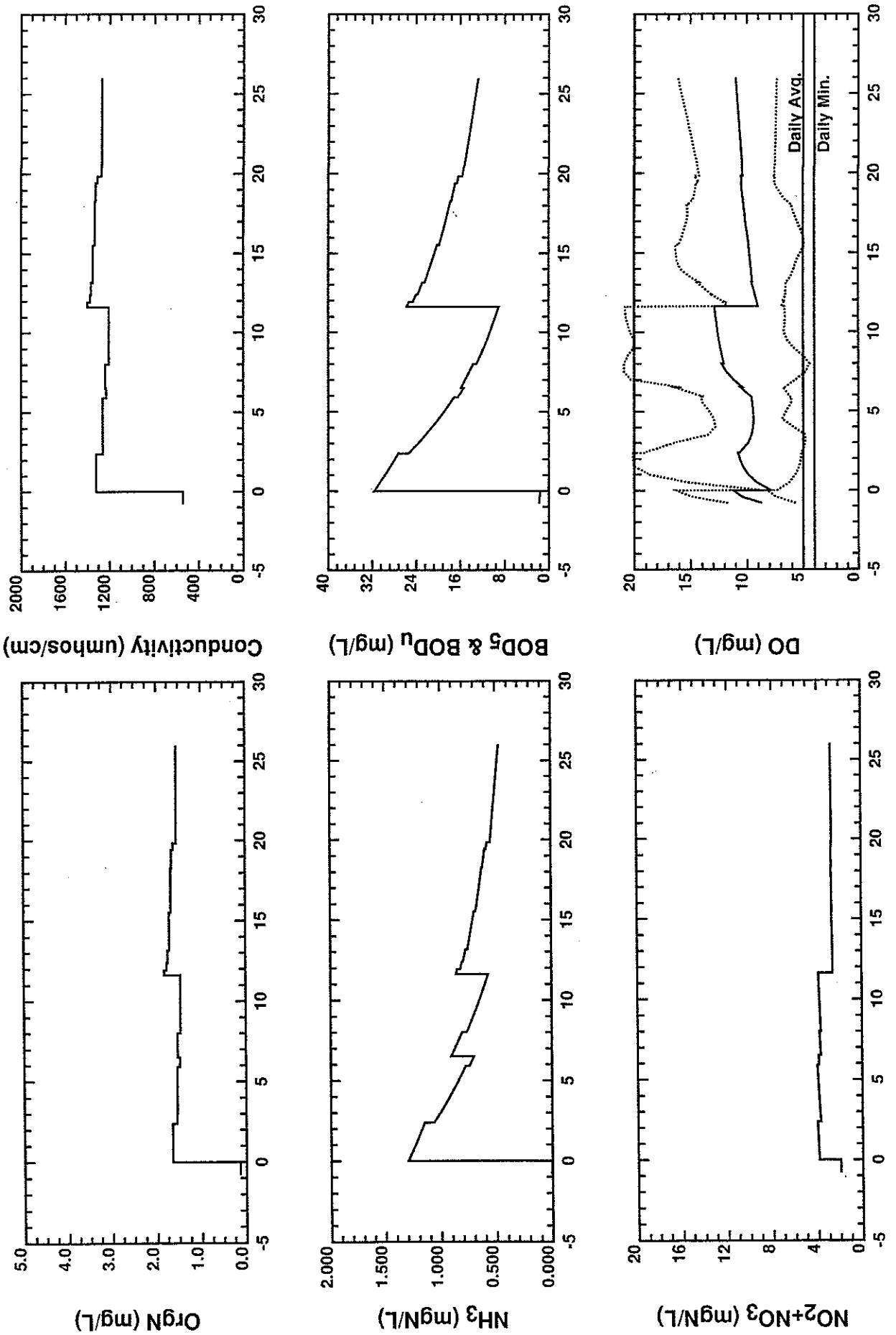
Ergoge Project Greek Water Quality Projections Tier 1 - Scenario 2



**Figure : Opequon Creek Water Quality Projections Tier 1 - Scenario 3
Change Pmax in Seg 4 and 5**

DATE: 2/23/2005 TIME: 9:38:53

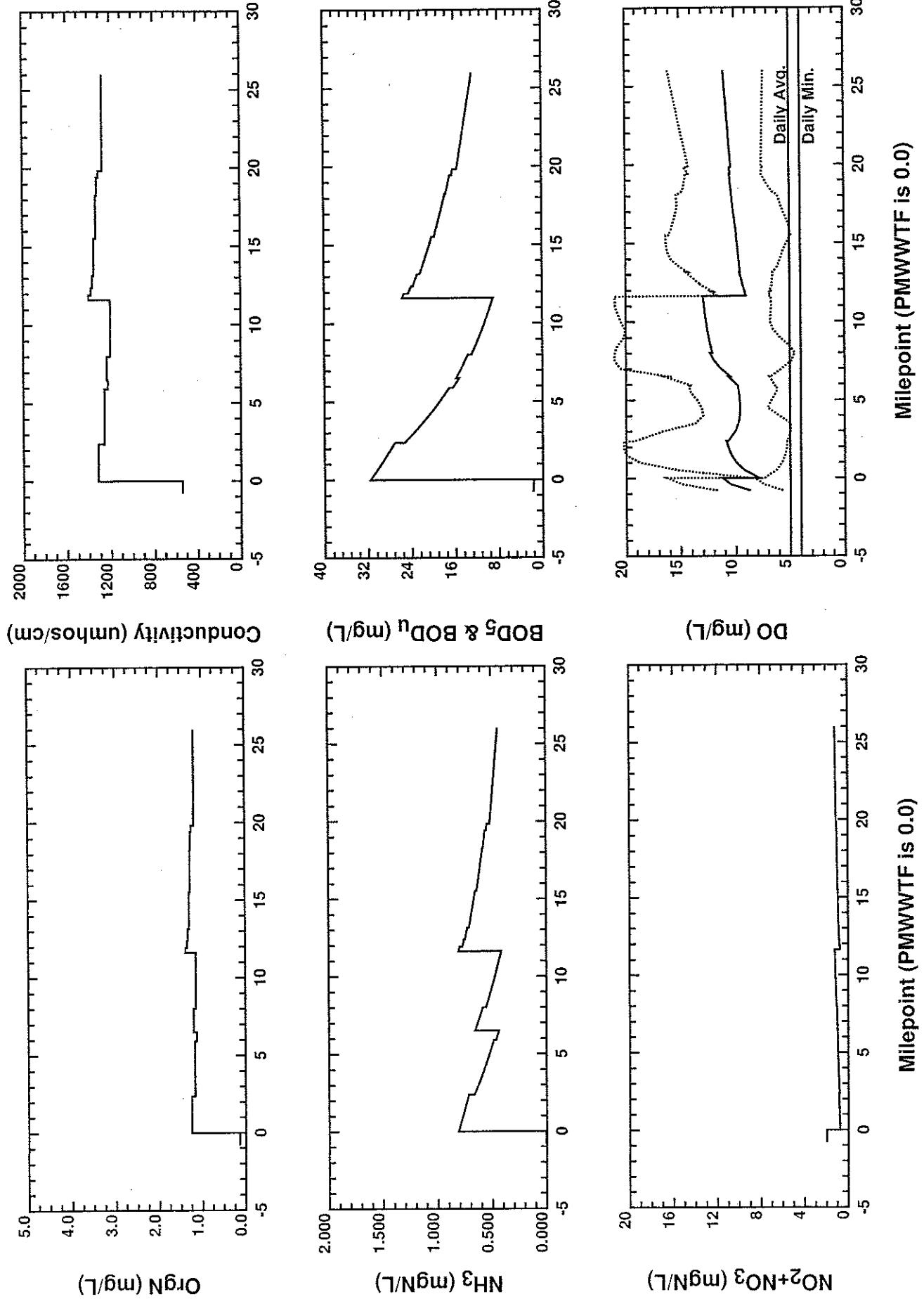
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**Figure : Opequon Creek Water Quality Projections Tier 1 - Scenario 4
Change · Pmax in Seg 4 and 5**

DATE: 2/23/2005 TIME: 9:32:15

/usersnm/obag0060/HEIDI/MODEL/PROJECTION/TIER1/t1s4.gdp



**Figure : Opequon Creek Water Quality Projections Tier 1 - Scenario 5
Change Pmax in Seg 4 and 5**

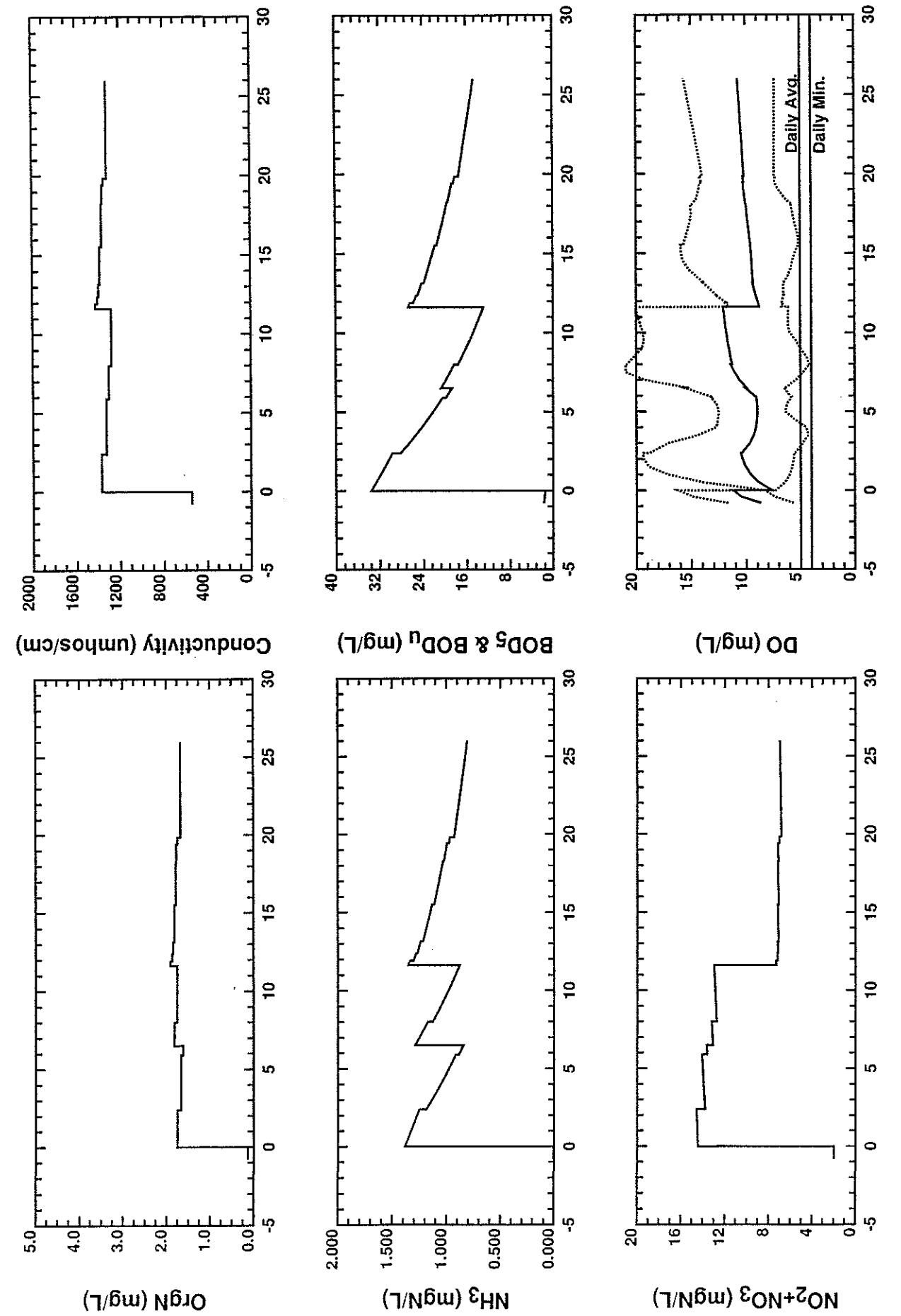
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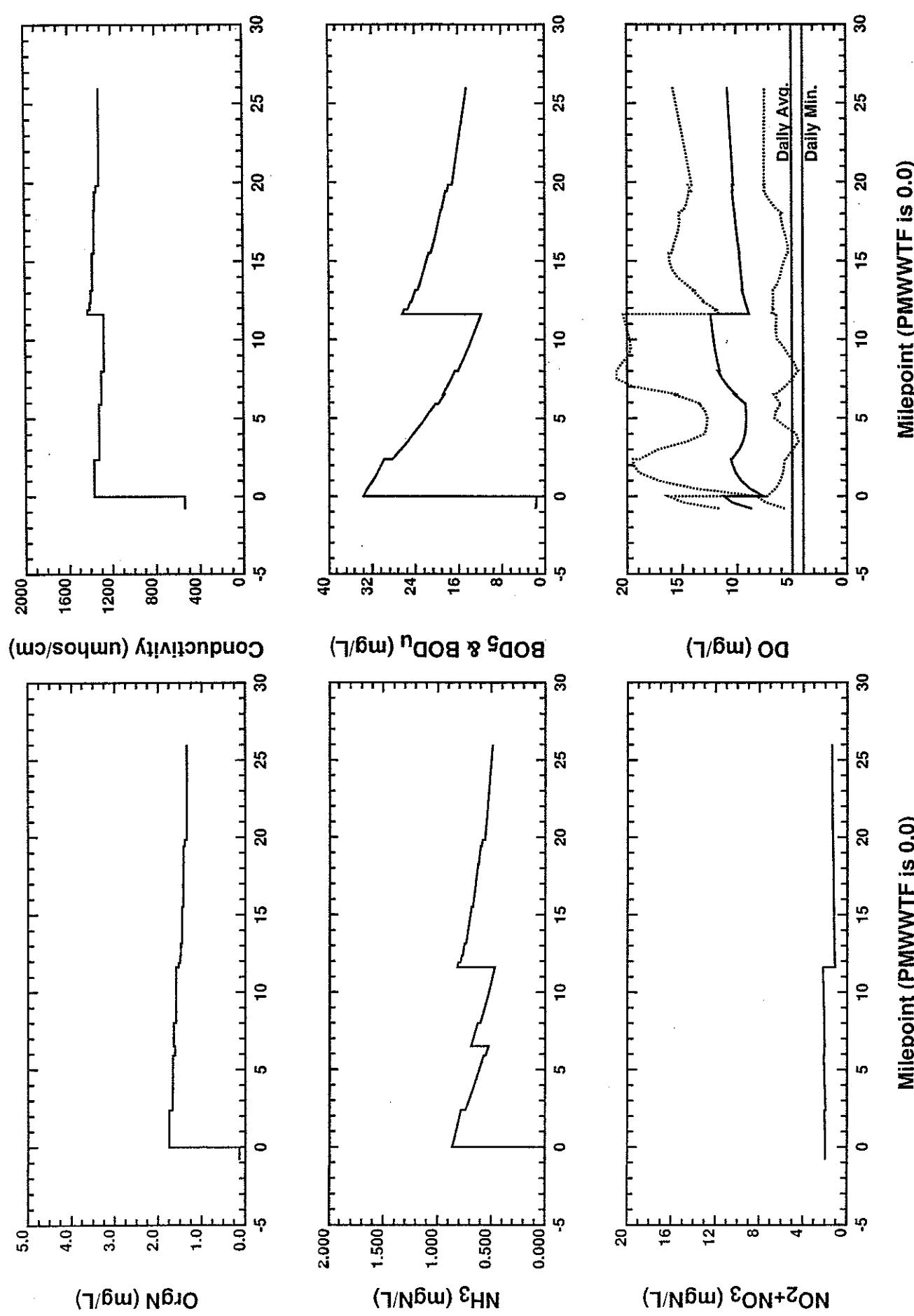
APPENDIX 7

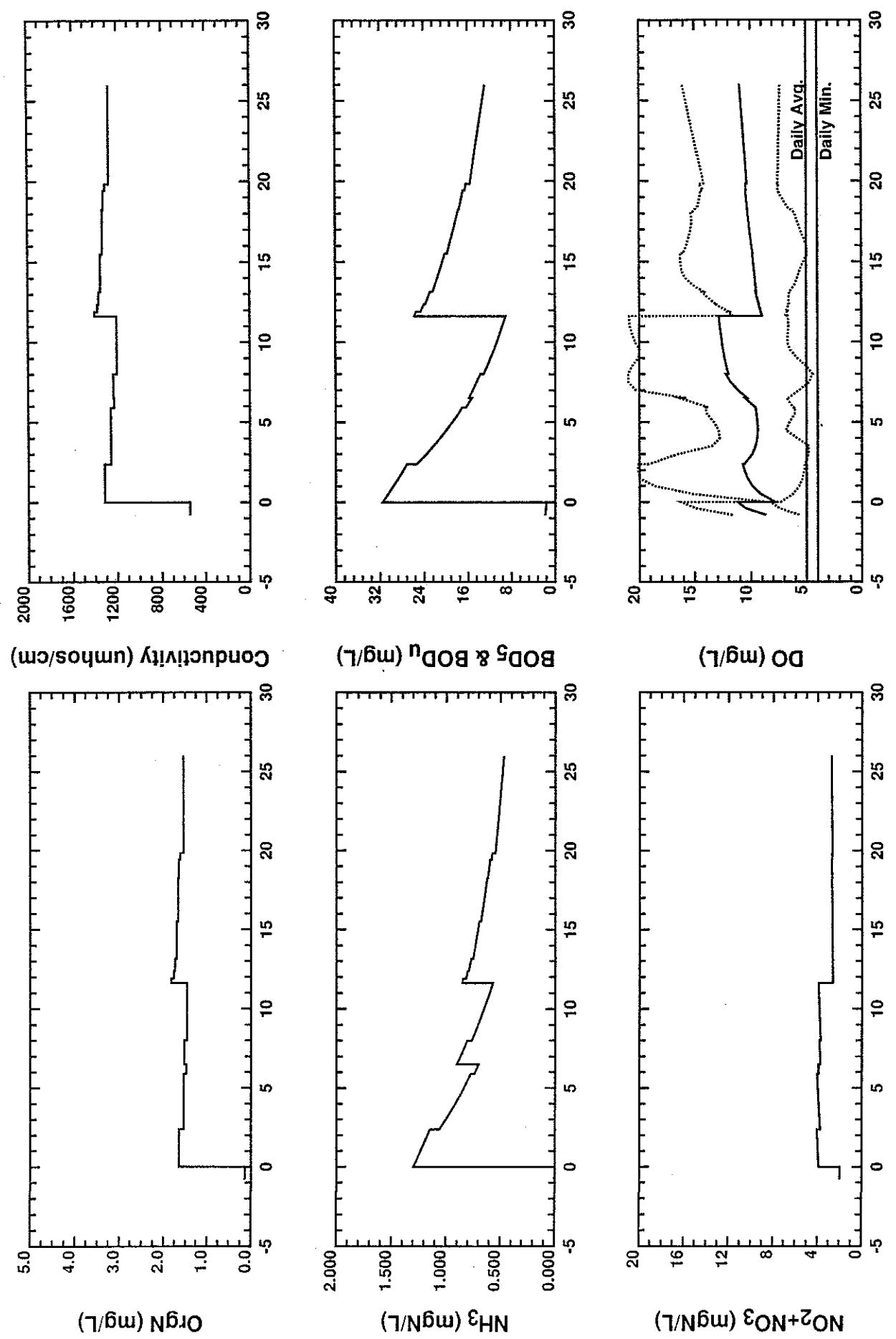
TIER 2, SCENARIOS 1-5 SUNNY CONDITIONS

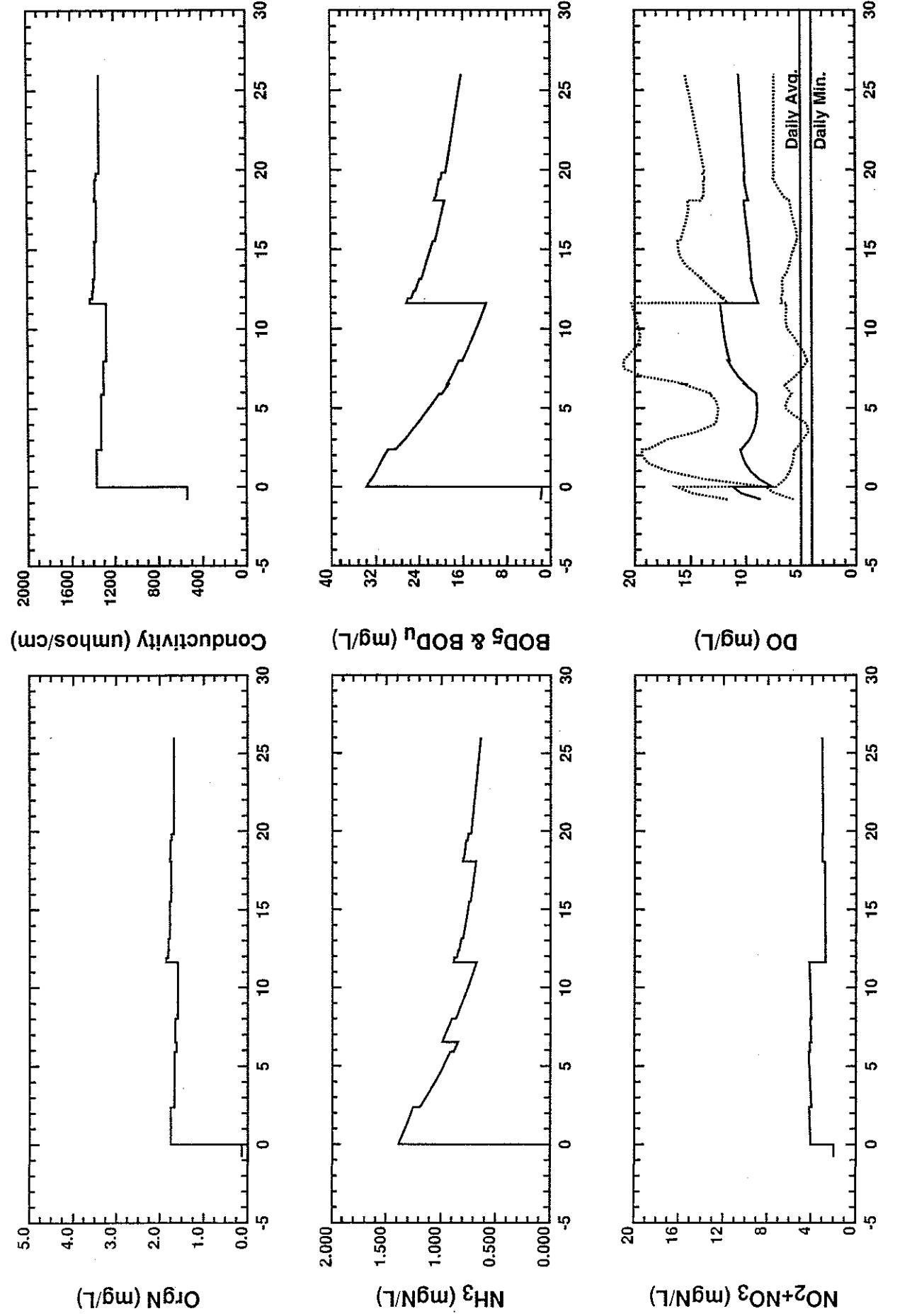


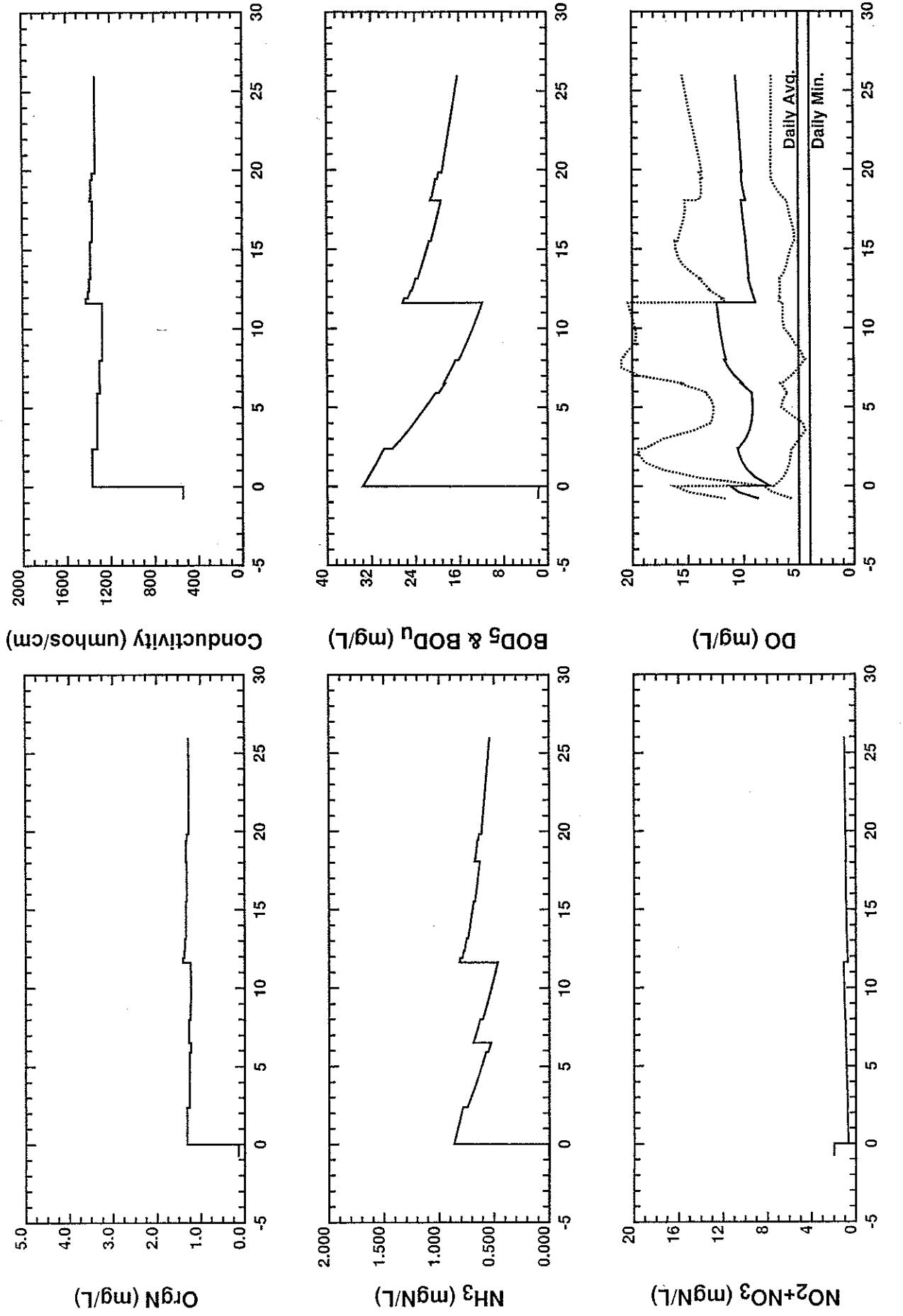
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Tier 2 - Scenario 5 - Sunny Day

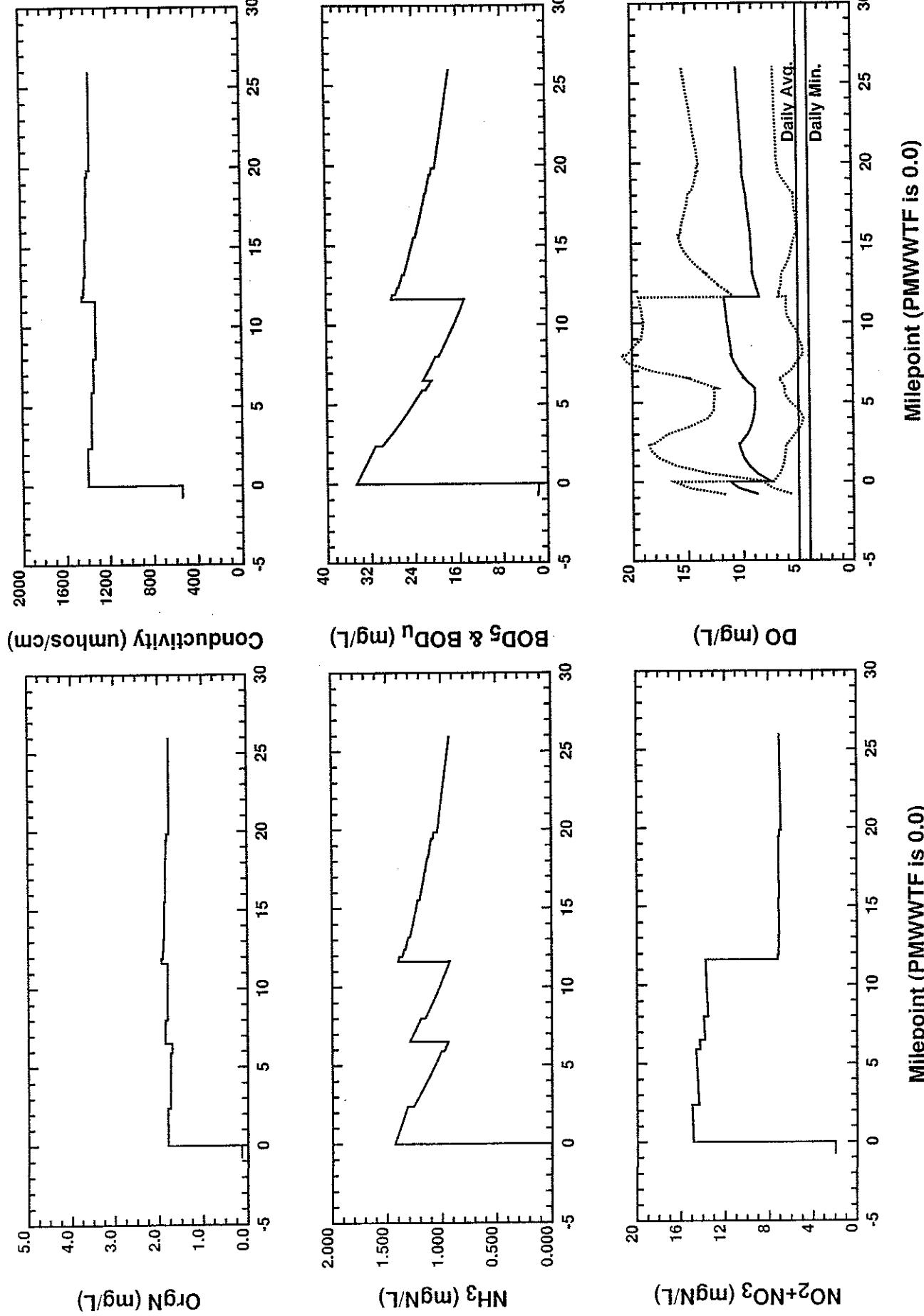
Figure . Opequon Creek Water Quality Projections
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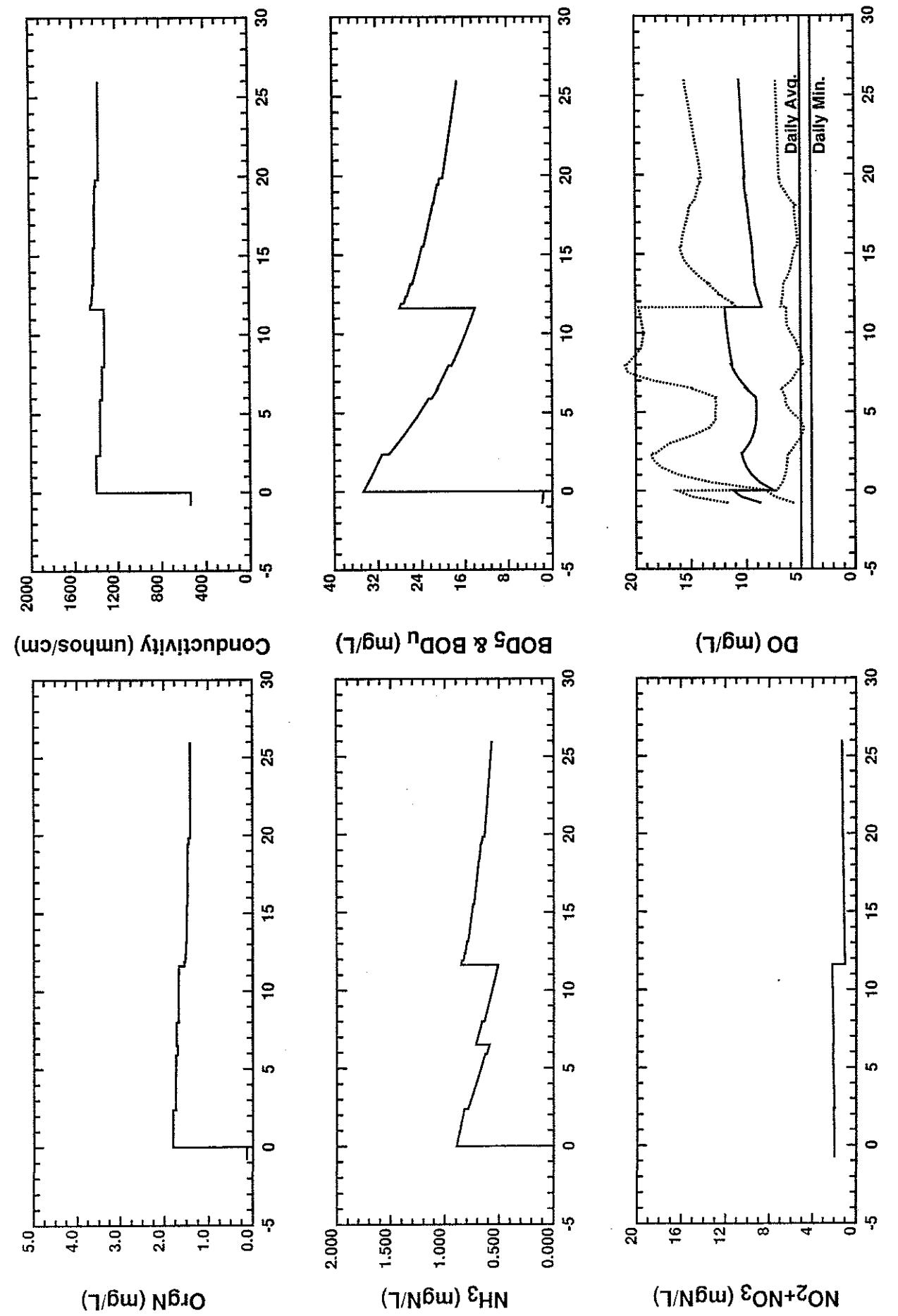
APPENDIX 8

TIER 3, SCENARIOS 1-5 SUNNY CONDITIONS

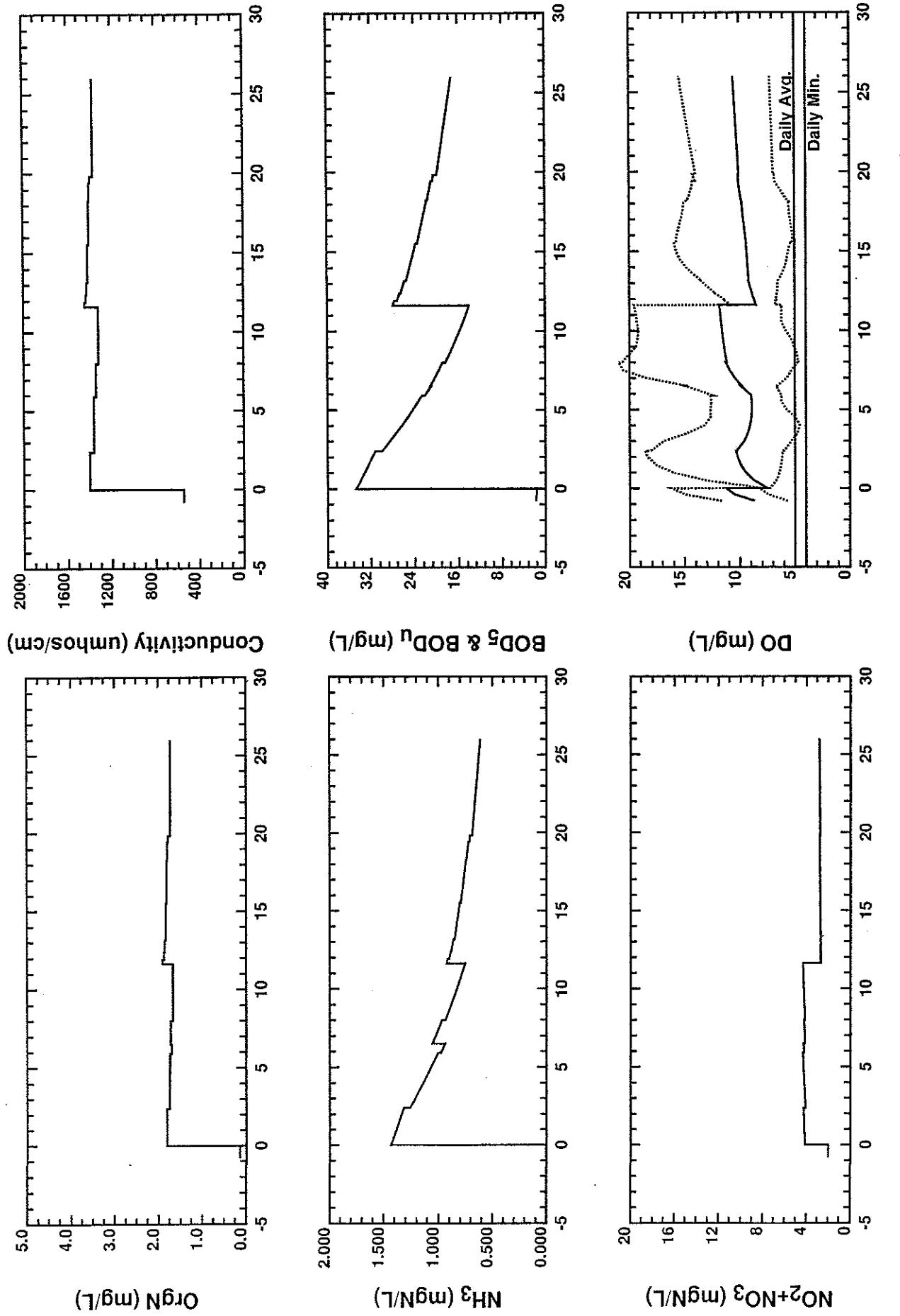


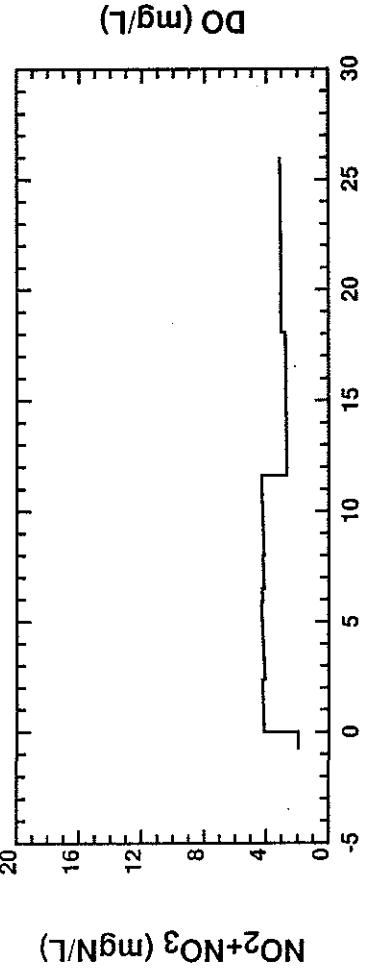
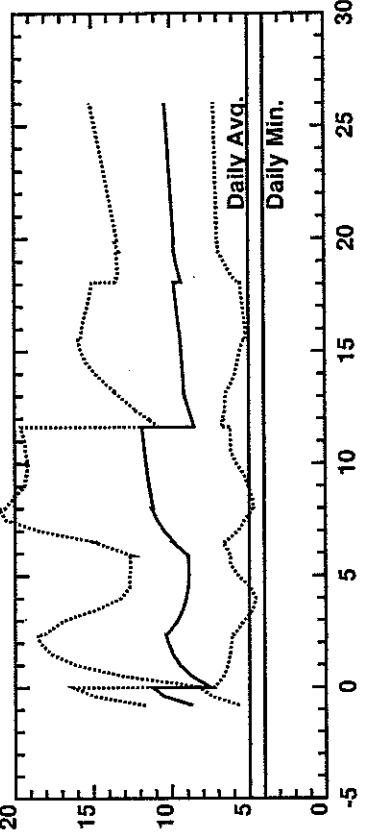
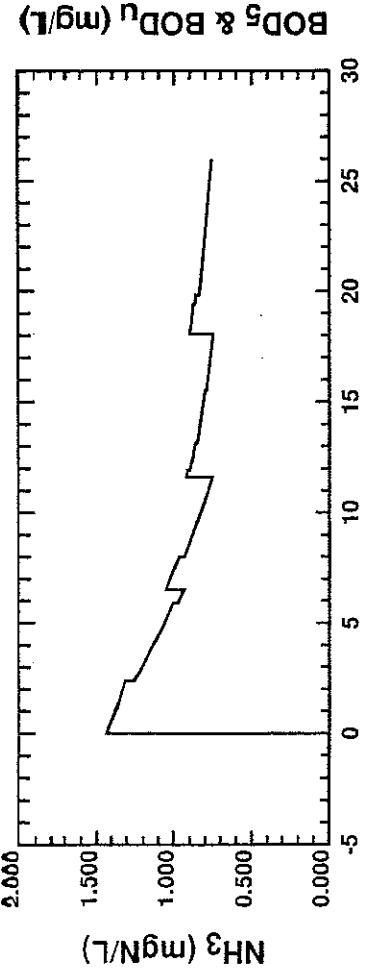
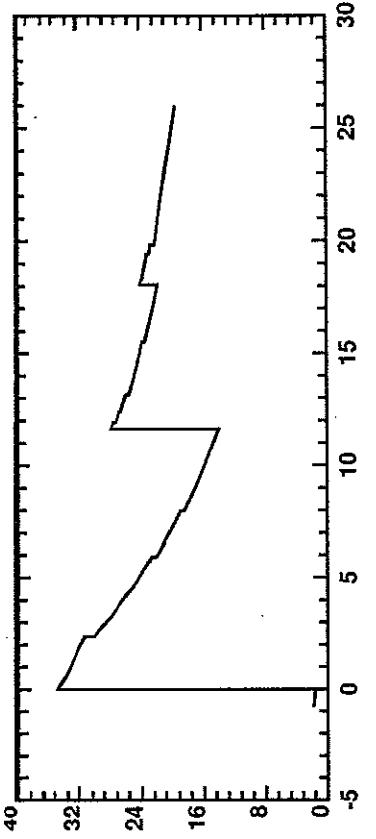
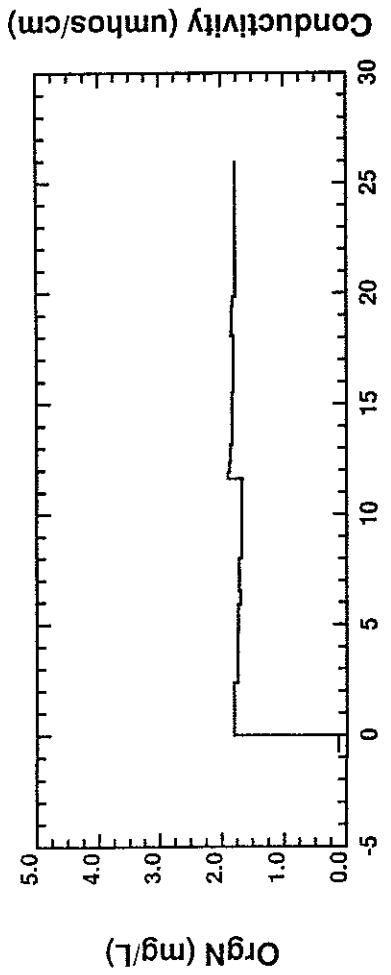
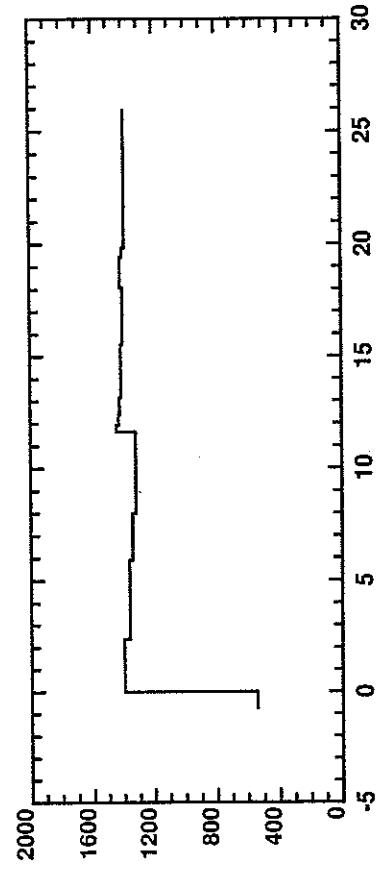
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DATE: 2/23/2005 TIME: 14:50:36
 /users/m/obag0060/HEIDI/MODEL/PROJECTION/TIER3/SUNNYBAT





Milepoint (PMWWTF is 0.0)

Tier 3 - Scenario 4 - Sunny Day

Figure . Opequon Creek Water Quality Projections

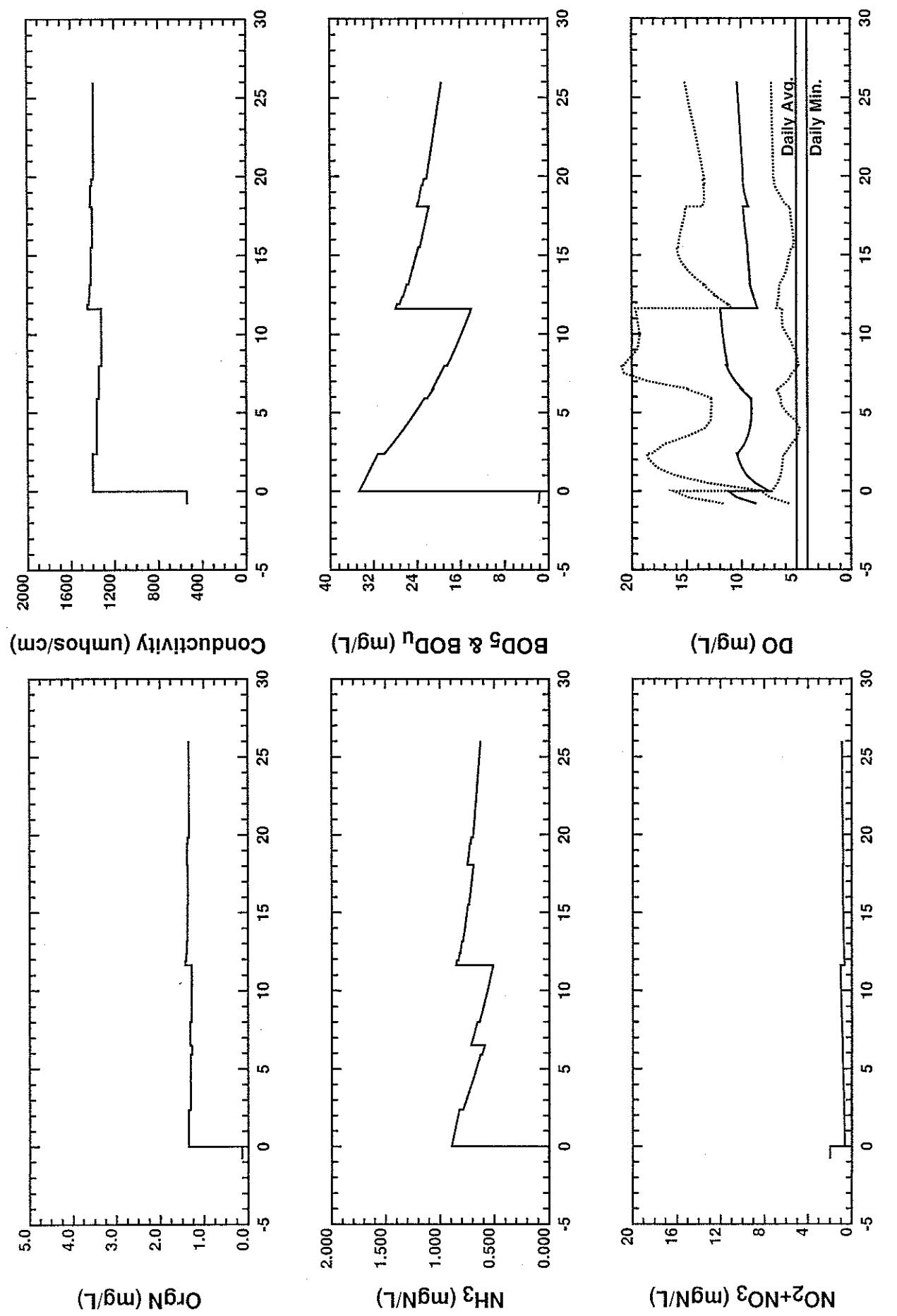


Figure . Opequon Creek Water Quality Projections
 /users/m/bag0060/HEIDY/MODEL/PROJECTION/TIER3/SUNNY_B/
 DATE: 2/23/2005 TIME: 14:50:43

APPENDIX 9

TIER 4, SCENARIOS 1-5 SUNNY CONDITIONS



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